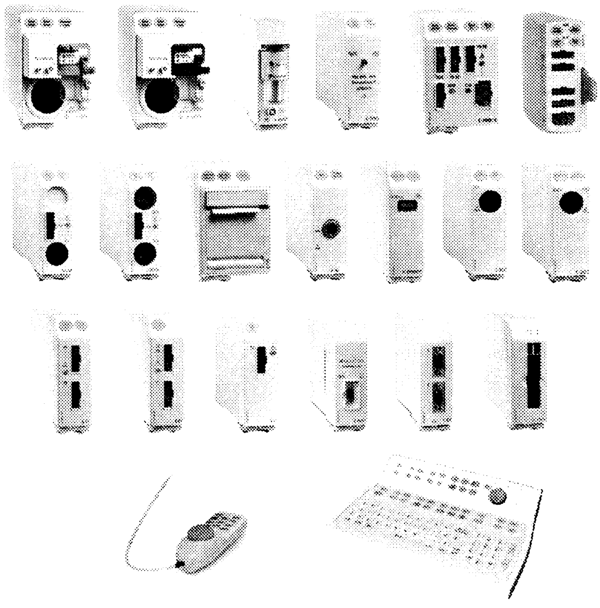
Datex-Ohmeda

S/5™ E-Modules

Technical Reference Manual



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M1021573
June, 2005

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A portion of the Entropy software is derived from the RSA Data Security, Inc. MD5 Message-Digest Algorithm.

Datex-Ohmeda E-Modules

Technical Reference Manual, Order code: M1021573

Document No.	Updated	Description	
M1027822		Compact Airway Modules, E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV and E-CO	1
M1027824		PRESTN Modules, E-PRESTN, E-RESTN, E-PRETN	2
M1024662-4		Patient Side Modules, E-PSM, E-PSMP	3
M1027825		Cardiac Output Modules E-COP and E-COPSv	4
M1027826		Pressure Module, E-P, Pressure Temp Module, E-PT	5
M1027827		Dual Pressure Module, E-PP	6
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About this manual

Notes to the reader

This Technical Reference Manual is intended for service personnel and engineers who will service and maintain the Datex-Ohmeda E-Modules as well as the anesthesia record keeping keyboard, K-ARKB, remote controllers, K-REMCO and K-CREMCO, Device Interfacing Solution, N-DISxxx, keyboard interface board, B-ARK, and ARK barcode reader, N-SCAN.

This Technical Reference Manual completes the S/5™ Anesthesia Monitor and S/5™ Critical Care Monitor Technical Reference Manual and the S/5™ Compact Anesthesia Monitor and S/5™ Compact Critical Care Monitor Technical Reference Manual. Later in this manual, the monitors may be referred to as AM, CCM, CAM and CCCM.

The order code for the entire printed manual is M1021573. Each product is described in its own slot, has an individual document number and is available for downloading from Extranet in Adobe Acrobat PDF format.

- This Technical Reference Manual contains the information needed to maintain, service and troubleshoot these products. Instructions for visual and functional inspection, disassembly and reassembly as well as calibration of the modules are included. A service check form for each product is included in the slots.
- In addition, this Technical Reference Manual contains detailed module specifications and descriptions on the technical performance and functioning of the modules.
- Read the manual through and make sure that you understand the procedures described before servicing the modules. To avoid risks concerning safety or health, strictly observe the warning indications. If you need any assistance concerning the service, please do not hesitate to contact your authorized distributor.

For information on safety precautions and symbols on equipment, installation, planned maintenance and interfacing, refer to the AM and CCM Technical Reference Manual or the CAM and CCCM Technical Reference Manual.

The manufacturer reserves the right to change product specifications without prior notice. Although the information in this manual is believed to be accurate and reliable, the manufacturer assumes no responsibility for its use.

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Related documentation

S/5 AM, CCM Technical Reference Manual

S/5 Anesthesia Monitor

For more specific information about the clinical aspects refer to:
S/5 Anesthesia Monitor, User's Guide
S/5 Anesthesia Monitor, User's Reference Manual

For more specific information about other devices closely related to the S/5 Anesthesia Monitor refer to:
iCentral, User's Reference Manual

S/5 Critical Care Monitor

For more specific information about the clinical aspects refer to:
S/5 Critical Care Monitor, User's Guide
S/5 Critical Care Monitor, User's Reference Manual

S/5 M-Modules

S/5 M-Modules Technical Reference Manual

Conventions used

Throughout this manual, the following conventions are used to distinguish procedures or elements of text:

✍	Sign the check form after performing the procedure.
Hard Keys	Hard key names on the Command Board, the Remote Controller and modules are written in the following way: **ECG**.
Menu Items	Menu items are written in bold italic: ***ECG Setup***.
'Messages'	Messages displayed on the screen are written inside single quotes: 'Please wait'.
"Sections"	When referring to different sections in the same manual, the section name is enclosed in double quotes: section "Cleaning and Service."
"Other documents"	When referring to different documents, the document name is enclosed in double quotes: refer to "User's Reference Manual".
Hypertext links	Hypertext links on PDF versions are written in blue color.
WARNING	Warnings are written in the following way:
WARNING	**Make sure that the electrodes, sensor and connectors do not touch any electrically conductive material, including earth.**
CAUTION	Cautions are written in the following way:
CAUTION	The module electronics can only be repaired and calibrated at the factory.
NOTE	Notes are written in following way: NOTE: Handle all PC boards by their edges.

In this manual, the word "select" means choosing and confirming.

1 Introduction

The E-series modules are white modules with GE parameter connectors for ECG, Sp02, NIBP, temperature and invasive blood pressure measurements.

The modules are designed for use with Datex-Ohmeda S/5™ Anesthesia Monitor, S/5™ Critical Care Monitor, S/5™ Compact Anesthesia Monitor, and S/5™ Compact Critical Care Monitor. Additionally, the E-PSM(P) module is also designed for use with Datex-Ohmeda S/5™ FM.

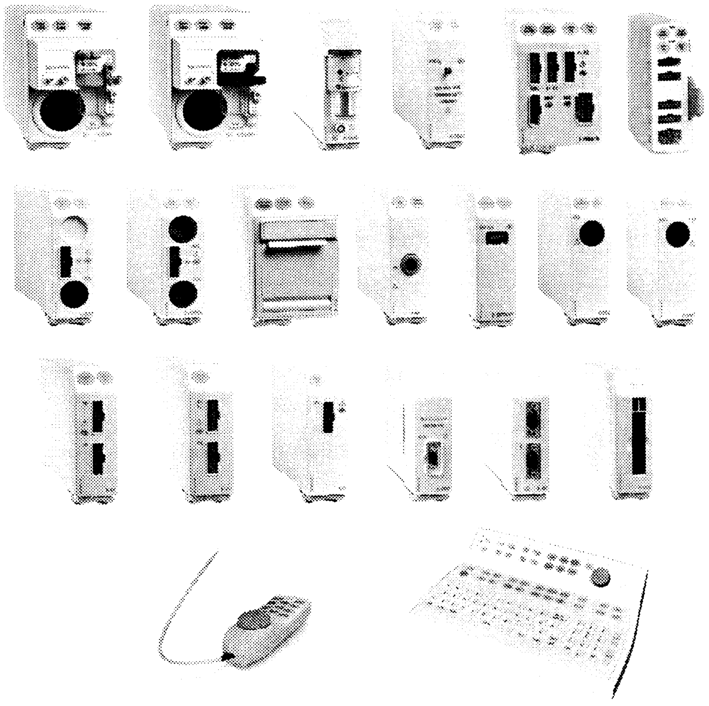


Figure 1 Datex-Ohmeda parameter E-modules, record keeping keyboard and Remote Controller

Plug-in modules

The E-modules are plug-in modules that can be plugged into F-CU8 and F-CU5(P) Module Frames. The modules can be removed or inserted during monitoring.

NOTE: The M-series and E-series measurement modules can both be used in the F-CU8 and F-CU5(P) Module Frames.

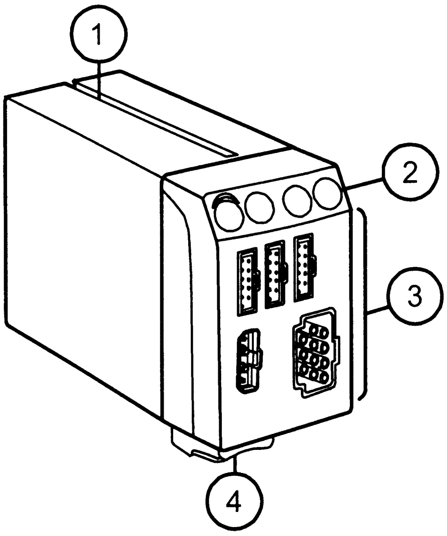


Figure 2 **General module description**

(1) Insertion guide slot
(2) Module keys
(3) Cable connectors
(4) Module release latch

The F-CU8 Module Frame provides places for up to four double-width or eight single-width modules. The F-CU5(P) Module Frame provides places for up to five single-width or two double-width modules (plus one slot for one single-width module). Up to two F-CU5(P) Module Frames can be connected together, thus providing ten single width module slots. The Extension Frame used with F-CU8 provides four additional module places.

Patient Side Module

Datex-Ohmeda Patient Side Module, E-PSM(P) Rev.00 is designed for use with Datex-Ohmeda monitors as follows:

- S/5 FM monitors using software L-FICU03(A) or later.
- S/5 Anesthesia Monitors using software L-ANE04(A) equipped with 5-Module Frame, F-CU5P or with 8-Module Frame, F-CU8. With F-CU8, the E-INTPSM interface module is needed.
- S/5 Critical Care Monitors using software L-ICU04(A) equipped with 5-Module Frame, F-CU5P or with 8-Module Frame, F-CU8. With F-CU8, the E-INTPSM interface module is needed.

Keyboards

Monitoring is controlled through the keys on the detachable Command Bar, fixed command board, anesthesia record keeping keyboard, Remote Controller and modules.

Remote Controller

The Remote Controller, K-(C)REMCO, brings the Command Bar functions near to the user and gives access to the same menus as the Command Bar.

The Remote Controller has keys that start or end a function immediately, like module keys. These direct access keys help in most common situations and tasks.

Module overview

The same modules can be used in the Anesthesia Monitor, Compact Anesthesia Monitor, Critical Care Monitor and Compact Critical Care Monitor. The patient accessories for the modules are the same as well.

Most of the modules contain several parameters. The following tables show the parameters for each module. The asterisk (*) in the parameter column indicates that the module measures the parameter referred to in the column heading. A number in the parameter column indicates that the module measures the parameter referred to in the column heading and the number of module connectors for that specific parameter.

Measurement modules

	12-lead ECG	**ECG**	**Inv. BP**	**SpO_2**	**Temp.**	**NIBP**	**Imp. resp.**	**C.O./REF**	**SvO_2**
E-PRESTN	*	up to 12 leads	2	*	2	*	*		
E-PRETN	*	up to 12 leads	2		2	*	*		
E-RESTN	*	up to 12 leads		*	2	*	*		
E-PSM	*	up to 12 leads		*	2	*	*		
E-PSMP	*	up to 12 leads	2	*	2	*	*		
E-P			1						
E-PP			2						
E-PT			1		2				
E-COP			1					*	
E-COPSv			1					*	*
E-NSAT				*					

	Relaxation	**Plexus stimul.**	**EEG**	**AEP**	**Entropy**	**Tonometry**	**BIS**
E-NMT	*	*					
E-EEG			*	*			
E-TONO						*	
E-BIS							*
E-ENTROPY					*		

	CO_2	N_2O	O_2	Anesth. agents	Agent identif.	Spirometry	Gas exchange
E-CO	*	*	*				
E-COV	*	*	*			*	
E-CAiO	*	*	*	*	*		
E-CAiOV	*	*	*	*	*	*	
E-CAiOVX	*	*	*	*	*	*	*
E-miniC	*						

Other modules

You can also use the following modules:

- Recorder Module, E-REC. If the monitor already has a built-in recorder, you cannot use the E-REC. In addition, E-REC cannot be used with certain Compact Monitor versions. If it does not work with your monitor, please contact service personnel for possible upgrade.
- Memory Module, E-MEM
- Interface Module, E-INT
- Blank module to fill the empty spaces of the frame without adding parameters

Avoiding identical modules

Modules that measure the same parameter are considered identical. Do not use them in the same monitor simultaneously.

NOTE: Corresponding M-series and E-series modules are considered identical.

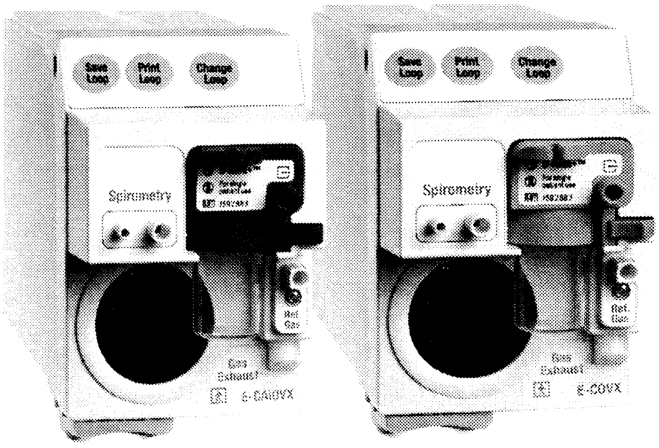
To monitor:	**Select only one of the following modules:**
ECG (E), NIBP (N), SpO2 (S), Temp (T), Pressure (P) or Resp (R)	E-PRESTN, E-PRETN, E-RESTN, E-PSM or E-PSMP. NOTE: E-PRESTN, E-PRETN, E-RESTN, E-PSM and E-PSMP work only with L-ANE04(A) and L-ICU04(A) software or later versions.
Pressure (P)	E-P or E-PT. NOTE: E-P or E-PT can be used together with E-PRESTN, E-PRETN, E-RESTN, E-PSM, E-PSMP or E-PP. NOTE: E-PP can be used for additional pressure measurements with E-P. E-PT, E-PRESTN, E-PRETN, E-RESTN, E-PSM and E-PSMP.
Separate SpO_2 measurement	E-NSAT NOTE: E-NSAT can be used with E-PRESTN, E-RESTN, E-PSM and E-PSMP. The SpO_2 measurement in E-NSAT automatically overrides the SpO_2 measurement in these modules.
C.O. (CO), Pressure (P) or SvO_2 (Sv)	E-COP or E-COPSv
CO_2 and N_2O (C), O_2 (O), Spirometry (V), anesthetic agents and nitrous oxide (A), agent identification (i), Gas Exchange (X)	E-CO, E-COV, E-COVX, E-CAiOVX, E-CAiOV, E-CAiO, E-miniC
Tonometry ($PgCO_2$)	E-TONO
NMT	E-NMT
EEG, AEP	E-EEG
BIS	E-BIS
Entropy	E-ENTROPY

Datex-Ohmeda

Compact Airway Modules

S/5™ Compact Airway Module, E-CAiOVX (Rev. 00)
S/5™ Compact Airway Module, E-CAiOV (Rev. 00)
S/5™Compact Airway Module, E-CAiO (Rev. 00)
S/5™ Compact Airway Module, E-COVX (Rev.00)
S/5™ Compact Airway Module, E-COV (Rev. 00)
S/5™ Compact Airway Module, E-CO (Rev. 00)

Technical Reference Manual Slot


Save Loop
Print Loop
Change Loop
Spirometry
Ref. Gas
Gas Exhaust
E-CAiOVX
Save Loop
Print Loop
Change Loop
Spirometry
Ref. Gas
Gas Exhaust
E-COVX

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Compact Airway modules. The Compact Airway modules are double width plug-in modules. E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX and E-CAiOVX/SERVICE are designed for use with the S/5 Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The Compact Airway modules provide airway and respiratory measurements.

Letters in the module name stand for:

C = CO_2 and N_2O, O = patient O_2, V = patient spirometry, X = gas exchange, A = anesthetic agents, and i = agent identification

About E-CAiOVX/SERVICE module

The E-CAiOVX/SERVICE module is meant for service purposes only. It can be used as a loan module, if the module in the hospital should be sent to the factory for repair. The specifications that apply to the E-CAiOVX apply also to the E-CAiOVX/SERVICE module. **Module differences: the colour of the front mask is green, the front panel has a "SERVICE" text and there are no front panel keys equipped.

Table 1 Options for Compact Airway modules

Modules	**Parameters/measurements**						
	CO_2	**N_2O**	**O_2**	**Anesthetic agents**	**Agent ID**	**Spirometry**	**Gas exchange**
E-CAiOVX	X	X	X	X	X	X	X
E-CAiOV	X	X	X	X	X	X	
E-CAiO	X	X	X	X	X		
E-COV	X	X	X			X	
E-COVX	X	X	X			X	X
E-CO	X	X	X				
E-CAiOVX/SERVICE	X	X	X	X	X	X	X

NOTE: Do not use identical modules in the same monitor simultaneously.
The E-miniC, E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX and E-CAiOVX/SERVICE and the M-miniC, M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX and M-CAiOVX/SERVICE are considered identical modules.

NOTE: The Compact Airway Module or Single-Width Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: The Compact Airway modules cannot be used in the Extension Frame, F-EXT4.

NOTE: Anesthetic agents and N_2O values are not displayed with Critical Care main software, but when present in the module they are calculated for compensation of CO_2 and O_2.

1 Specifications

1.1 General specifications

Module size, W × D × H	75 x 228 × 112 mm, 3.0 × 9.0 × 4.4 in
Module weight	1.6 kg/3.5 lb.
Operating temperature	+10...+40 °C
Storage temperature	-25...+70 °C
Atmospheric pressure	666...1060 hPa / (67...106 kPa) (500...800 mmHg) (666...1060 mbar)
Humidity	10...95% non-condensing (in airway 0...100%, condensing)
Power consumption	12.6 W Prms, 14.6 W momentary
Protection against electrical shock	Type BF

1.2 Typical performance

CO_2

Measurement range	0...15 vol% (0...15 kPa, 0...113 mmHg)
Measurement rise time	< 400 ms typical
Accuracy	≤ 0.2 vol% +2% of reading)
Gas cross effects	< 0.2 vol% (O_2, N_2O, anesthetic agents)

If CO_2 concentration is below 0.1%, 0.0% is displayed.

O_2

Measurement range	0 to 100 vol%
Measurement rise time	< 400 ms typical
Accuracy	± (1 vol% + 2% of reading)
Gas cross effects	< 1 vol%; anesthetic agents < 2 vol%; N_2O
O_2 Fi-Et difference	resolution 0.1 vol%

N_2O

Measurement range	0 to 100%
Measurement rise time	< 450 ms typical
Accuracy	± (2 vol% + 2% of reading)
Gas cross effects	< 2 vol%; anesthetic agents

Respiration Rate (RR)

Measurement range	4...60 breaths/min
Detection criteria	1% variation in CO_2

Anesthetic Agents (AA)

Measuring range	
Hal, Enf, Iso	0 to 6 vol%
Sev	0 to 8 vol%
Des	0 to 20 vol%
Measurement rise time	< 400 ms typical
Accuracy	±(0.15 vol% +5% of reading)
Gas cross effects	< 0.15 vol% N_2O

Resolution is two digits, when the AA concentration is below 1.0 vol%.
If AA concentration is below 0.1 vol%, 0.0% is displayed.

Identification threshold	0.15 vol% typical
Identification time	< 20 s (for pure agents)

Mixture identification threshold for 2. agent:
0.2 vol% +10% of total conc.

MAC

Range	0...9.9 MAC

Equation:

$$MAC(AA) = \frac{\%(ETAA)}{x(AA)} + \frac{\%ETN_2O}{100}$$

Formula 1

where x(AA): Hal=0.75%, Enf=1.7%, Iso=1.15%, Sev=2.05%, Des=6.0%.

1.3 Gas specifications

Airway humidity	0...100%, condensing
Sampling rate	200 ±20 ml/min. (sampling line 2-3 m, normal conditions)
Sampling delay	2.5 seconds typical with a 3 m sampling line
Total system response time	2.9 seconds typical with a 3 m sampling line, including sampling delay and rise time
Display update rate	breath-by-breath

Automatic compensation for pressure, CO_2-N_2O and CO_2-O_2 collision broadening effect

Warm up time	2 min. for operation with CO_2, O_2, and N_2O
	5 min. for operation of anesthetic agents
	30 min. for full specifications
Auto zeroing interval	Immediately after calibrating the gas sensor and 2, 5, 10, 15, 30, 45, 60 minutes after start-up, then every 60 minutes

1.3.1 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

Ambient temperature	18...28 °C, within ±5 °C of calibration
Ambient pressure	500...800 mmHg, ±50 mmHg of cal.
Ambient humidity	20...80% RH, ±20% RH of cal.

Non-disturbing gases

- Ethanol C_2H_5OH(< 0.3%)
- Acetone (< 0.1%)
- Methane CH_4 (< 0.2%)
- Nitrogen N_2
- Carbon monoxide CO
- Nitric Oxide NO (< 200 ppm)
- water vapor

Maximum effect on readings

- $CO_2 < 0.2$ vol%
- O_2, $N_2O < 2$ vol%
- anesthetic agents < 0.15 vol%

Effect of Helium	decreases CO_2 readings < 0.6 vol% typically

1.3.2 Conditions exceeding normal

Accuracy specifications under the following conditions; ❶❷❸❹:

❶ Ambient temperature	10...40 °C, within ±5 °C of calibration
Ambient pressure	500...800 mmHg, ±50 mmHg of calibration
Ambient humidity	10...98% RH, ±20% RH of calibration

❷ During warm-up 2 to 10 minutes (anesthetic agents 5-10 minutes), under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

❹N20 > 85%, under normal conditions

	Accuracy under different conditions (see above)		
	Condition ❶ and ❸	Condition ❷	Condition ❹
CO_2	±(0.3 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.4 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)	
O_2	(2 vol% + 2% of reading)	±(3 vol% + 3% of reading)	
N_2O	±(3 vol% + 3% of reading)	±(3 vol% + 5% of reading)	± (2vol% + 8% of reading)
Agents: Hal, Enf, Iso, Sev, Des	±(0.2 vol% + 10% of reading)	±(0.3 vol% + 10% of reading)	

1.4 Patient spirometry specifications

1.4.1 Normal conditions

Accuracy specifications apply in normal conditions (after 10 minutes warm-up period):

Ambient temperature	10...40 °C
Ambient pressure	500...800 mmHg
Ambient humidity	10...98% RH
Airway humidity	10...100% RH

Respiration rate	4...35 breaths/min (adults) 4...50 breaths/min (pediatric)
I:E ratio	1:4.5...2:1
Intubation tube	5.5...10 mm (adults), 3...6 mm (pediatric)

Airway pressures (P_{aw}, P_{peak}, P_{plat}, $PEEP_e$, $PEEP_{IStat}$, $PEEP_{IDyn}$, P_{mean})

Measurement range	-20...+100 cmH_2O
Resolution	0.5 cmH_2O
Accuracy	±1 cmH_2O

Airway flow

Measurement range (for both directions)	1.5...100 l/min (adults) 0.25...25 l/min (pediatric)

Tidal volume

Measurement range	150...2000 ml (adults), 15...300 ml (pediatric)
Resolution	1 ml
Accuracy	±6% or 30 ml (adult), ±6% or 4 ml (pediatric)

Minute volume

Measurement range	2...20 l/min (adults), 0.5...5 l/min (pediatric)
Resolution	0.1 l/min

Compliance

Measurement range	4...100 ml/cmH_2O (adult), 1...100 ml/cmH_2O (pediatric)
Resolution	1 ml/cmH_2O (adult), 0.1 ml/cmH_2O (pediatric)

Airway resistance

Measurement range	0...40 cmH_2O/ l/s
Resolution	1 cmH_2O/ l/s

Other parameters

Specifications apply in conditions listed in patient spirometry specifications.

Dead space of the sensor

9.5 ml (adult), 2.5 ml (pediatric)

Resistance of the sensor

0.5 cmH_2O @ 30 l/min (adult), 1.0 cmH_2O @ 10 l/min (pediatric)

1.4.2 Conditions exceeding normal

Accuracy specifications under the following condition (during warm-up 2 to 10 minutes):

Airway Pressure (P_{aw})

Accuracy	±2 cmH_2O

Tidal volume

Accuracy	±10% or 100 ml (adult), ±10% or 10 ml (pediatric)

1.5 Gas exchange specifications

Mathematical integration of airway flow and gas concentration for intubated, mechanically ventilated and/or partly spontaneously breathing patients.

NOTE: These specifications apply only, when a 2 meter gas sampling line is used, and a Y-piece with a physical dead space less than 8 ml.

NOTE: These specifications only apply, if the FiO_2 level delivered to the patient is varying by less than 0.2% at the measurement point during the inspiratory cycle.

VO_2 and VCO_2

Measurement range	50...1000 ml/min
Resolution	10 ml/min
Accuracy	±10% or 10 ml; when $FiO_2 < 65\%$
	±15% or 15 ml; when $65\% < FiO_2 < 85\%$

RQ

Measurement range	0.6...1.2
Resolution	0.05

2 Functional description

2.1 Measurement principle

2.1.1 CO_2, N_2O, and agent measurement

TPX is a side stream gas analyzer, measuring real time concentrations of CO_2, N_2O and anesthetic agents (Halothane, Enflurane, Isoflurane, Desflurane, and Sevoflurane).

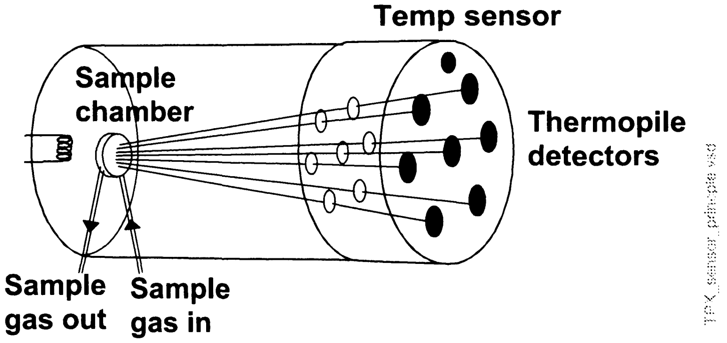


Figure 1 **TPX sensor principle**

Anesthetic agents or mixtures of two anesthetic agents are automatically identified and concentrations of the identified agents are measured. TPX also detects mixtures of more than two agents and issues an alarm.

TPX is a non dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters.

The infrared radiation detectors are thermopiles.

Concentrations of CO_2 and N_2O are calculated from absorption measured at 3-5 μm.

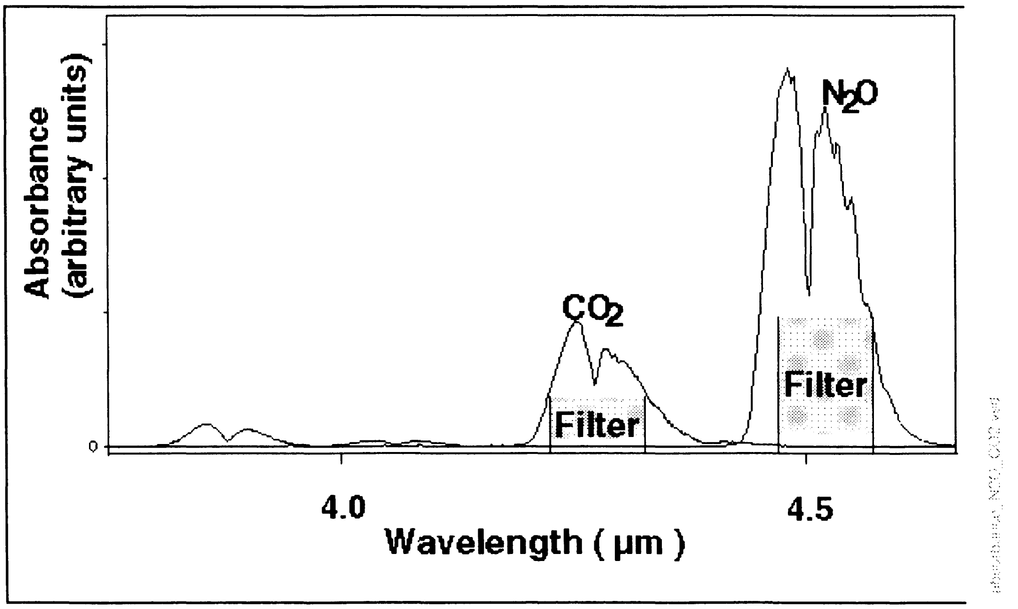


Figure 2 **Absorbance of N_2O and CO_2**

Identification of anesthetic agents and calculation of their concentrations is performed by measuring absorptions at five wavelengths in the 8-9 μm band and solving the concentrations from a set of five equations.

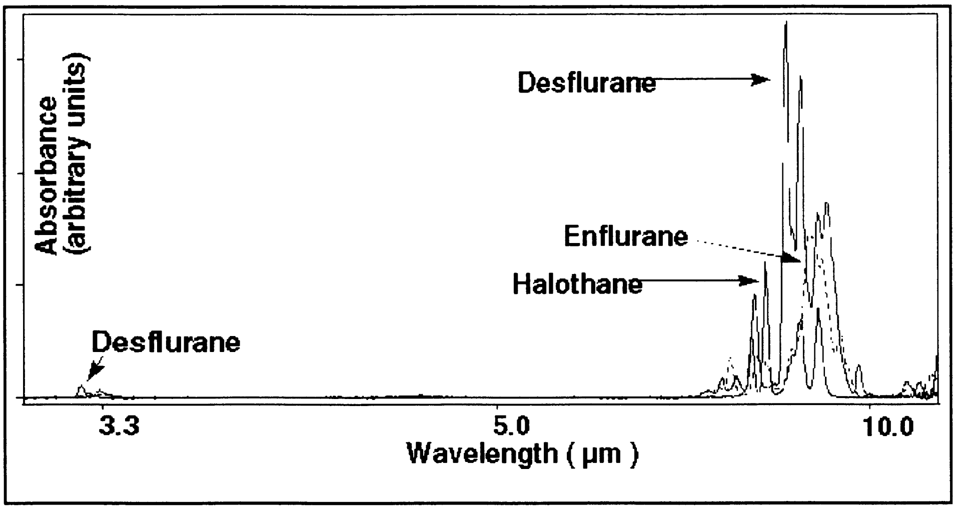


Figure 3 **Infrared absorbance of AAs**

The measuring accuracy is achieved utilizing numerous software compensations. The compensation parameters are determined individually for each TPX during the factory calibration.

2.1.2 O_2 measurement

The differential oxygen measuring unit uses the paramagnetic principle in a pneumatic bridge configuration. The signal picked up with a differential pressure transducer is generated in a measuring cell with a strong magnetic field that is switched on and off at a frequency of 165 Hz. The output signal is a DC voltage proportional to the O_2 concentration difference between the two gases to be measured.

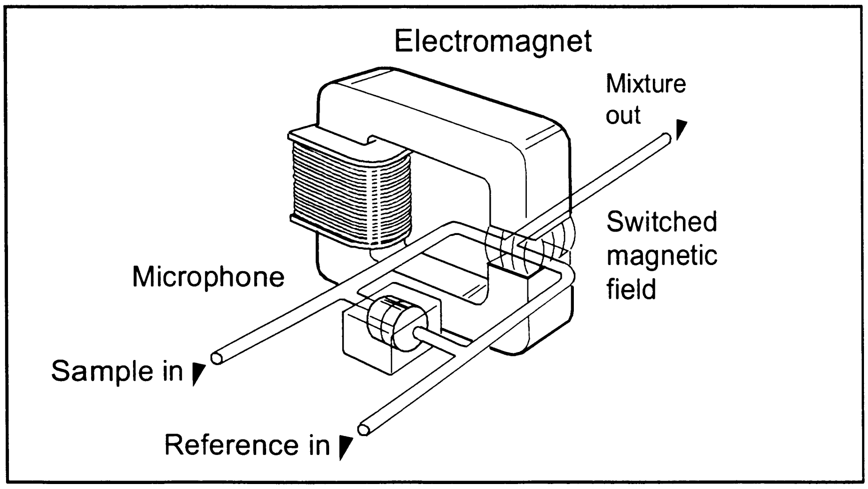


Figure 4 **O_2 measurement principle**

2.1.3 Patient spirometry

In mechanical ventilation, breaths are delivered to the patient by a ventilator with a proper tidal volume (TV), respiration rate (RR), and inspiration / expiration ratio in time (I:E) determined by the settings of the ventilator.

The Patient Spirometry monitors patient ventilation. The following parameters are displayed:

- Expiratory and inspiratory tidal volume (TV) in ml
- Expiratory and inspiratory minute volume (MV) in l/min
- Expiratory spontaneous minute volume in l/min
- Inspiration/expiration ratio (I:E)

Airway pressure

- Peak pressure (P_{peak})
- Mean airway pressure (P_{mean}); available only in S/5 Critical Care and Compact Critical Care monitors
- End inspiratory pressure (P_{plat})
- PEEPi, PEEPe; available only in S/5 Critical Care and Compact Critical Care monitors
- Total positive end expiratory pressure ($PEEP_{tot}$); available only in S/5 Anesthesia and Compact Anesthesia monitors
- Real time airway pressure waveform (P_{aw})
- Static Positive end expiratory pressures (Static $PEEP_i$ and Static $PEEP_e$); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Plateau pressure (Static Pplat); available only in S/5 Critical Care and Compact Critical Care monitors
- Static Compliance (Static Compl); available only in S/5 Critical Care and Compact Critical Care monitors

PEEP, P_{peak}, P_{mean}, and P_{plat} are measured by a pressure transducer on the PVX board. Atmospheric pressure is used as a reference in measurement. The pressure measurement is made from the airway part that is closest to the patient between the patient circuit and intubation tube.

$PEEP_i$=intrinsic PEEP, $PEEP_{tot}$-$PEEP_e$

Static pressure measurement maneuvers are automatically identified based on an increased zero flow period at the end of the inspiration or expiration.

Static Compliance is calculated, if Static PEEP and Static P_{plat} measurements were made within a 2 minute period.

Airway flow

- Real time flow waveform (V')
- Compliance (Compl)
- Airway resistance (Raw)
- Pressure volume loop
- Flow volume loop

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The pressure signal obtained is linearized and corrected according to the density of the gas. Speed of flow is calculated from these pressure values and the TV value is then integrated. The MV value is calculated and averaged using TV and RR (respiratory rate) values.

Compliance and airway resistance

Compliance is calculated for each breath from the equation

$$Compl = \frac{T_{exp}}{P_{plat} - PEEP_i - PEEP_e}$$

Formula 2

Compliance describes how large a pressure difference is needed to deliver a certain amount of gas to the patient.

The airway resistance, Raw, is calculated using an equation that describes the kinetics of the gas flow between the lungs and the D-lite. The equation states that the pressure at the D-lite can at any moment of the breath be approximated using the equation

$$\frac{P(t) = Raw \times V'(t) + V(t)}{Compl + PEEP_e + PEEP_i}$$

Formula 3

where P(t), V'(t) and V(t) are the pressure, flow and volume measured at the D-lite at a time t, Raw is the airway resistance, Compl is the compliance and $PEEP_e$+$PEEP_i$ is the total positive end expiratory pressure ($PEEP_{tot}$).

D-lite

Patient Spirometry uses specific sensors called D-lite+/D-lite and Pedi-lite+/Pedi-lite flow sensors. Different types of sensors are available: adult sensor for measuring adults and pediatric sensor for children. Both are available as reusable and disposable versions.

D-lite and Pedi-lite adapters are designed to measure kinetic pressure by a two-sided Pitot tube. Velocity is calculated from pressure difference according to Bernoulli's equation. Flow is then determined using the calculated velocity.

$$v = \sqrt{\frac{2 \times dP}{\rho}}$$

(from Bernoulli's equation) **Formula 4**

$$F = v \times A,$$

where:

F = flow (l/min), v = velocity (m/s), A = cross area (m^2), dP = pressure difference (cmH_2O),

ρ = density (kg/m^3)

Finally the volume information is obtained by integrating the flow signal.

2.1.4 Gas exchange measurement

The gas exchange measurement uses the D-lite flow sensor and the gas sampler.

The basic data which is needed to obtain O_2 consumption and CO_2 production are **volumes** and **concentrations**.

Concentrations have been corrected for delay and deformation during the transport of the gas sample in a sidestream gas measurement sensor.

To obtain the amount of O_2 consumed in ml/min, the amount which is exhaled is subtracted from the amount that is inhaled.

To obtain the amount of CO_2 produced in ml/min, the amount which is inhaled is subtracted from the amount that is exhaled.

These amounts can be obtained by multiplying each measured volume piece (dv) by the corresponding gas concentration:

$$VO2 = \int_{insp} f_{O_2} dv - \int_{exp} f_{O_2} dv$$

Formula 5

and

$$VCO2 = \int_{exp} f_{CO_2} dv - \int_{insp} f_{CO_2} dv$$

Formula 6

Using inspiratory and expiratory minute volumes MV_i and MV_e and volume-weighted inspiratory concentrations fi and fe, these equations can be rewritten as:

$$VO2 = fi_{O_2} \times MV_i - fe_{O_2} \times MV_e \quad [ml/min]$$

Formula 7

$$VCO2 = fe_{CO_2} \times MV_e - fi_{CO_2} \times MV_i \quad [ml/min]$$

Formula 8

To obtain results which are less sensitive to errors in volume measurements, the so-called *Haldane transformation* is used. This means taking advantage of the fact that the patient is not consuming nor producing nitrogen: the amount of nitrogen inhaled is equal to the amount exhaled $fi_{N2} \times MV_i = fe_{N2} \times MV_e$.
VO_2 and VCO_2 can then be written as:

$$VO2 = (fi_{O_2} - f_{Hald} \times fe_{O_2}) MV_i \quad [ml/min]$$

Formula 9

$$VCO2 = (f_{Hald} \times fe_{CO_2} - fi_{CO_2}) MV_i \quad [ml/min]$$

Formula 10

with

$$f_{Hald} = (1 - fi_{CO2} - fi_{O2} - fi_{N2O} - fi_{Ane1} - fi_{Ane2}) / (1 - fe_{CO2} - fe_{O2} - fe_{N2O} - fe_{Ane1} - fe_{Ane2})$$

$$EE = (5.5 \times VCO_2) + (1.76 \times VO_2) + (1.99 \times Un) \quad [kcal/day]$$

Formula 11

with Un=Urea Nitrogen Excretion = 13 g/day (for adults only).

2.2 Main components

The compact airway modules consist of:

- Gas sampling system
- TPX measuring unit
- OM measuring unit
- PVX measuring unit
- CPU board
- OM board
- PVX board

2.2.1 Gas sampling system

The sampling system takes care of drawing a gas sample into the analyzers at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to gas measuring units. After the measurements, the gas is exhausted from the sample gas out connector.

The E-COVX and E-CAiOVX modules have a different gas sampling system compared to the other modules. A number of flow restrictors have been changed to create a bigger pressure difference with ambient pressure in the gas sensors. The sample flow is, however, about the same (200 ml/min).

A larger pressure difference makes the deformations of the gas concentration curves less sensitive to high variations of the airway pressures, thus meeting also the accuracy requirements of gas exchange for these applications.

D-fend™

The sample is drawn through a sampling line. Then gas enters the monitor through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzers. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the D-fend water trap, which causes fluid removed by the hydrophobic filter to collect in the bottle.

Zero valve and absorber

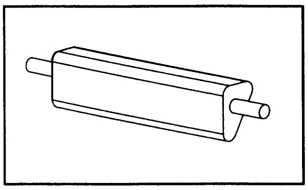


Figure 5 Absorber

The main flow passes through a magnetic valve before proceeding to the analyzers. This valve is activated to establish the zero points for the TPX and OM units. When the valve is activated, room air is drawn through the absorber into the internal system and the gas sensors. Paralyme is used as an absorbent.

Nafion™ tubes [1]

A Nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube will prevent errors caused by the effect of water vapor on gas partial pressure, when humid gases are measured after calibration with dry gases. Another Nafion tube is used between the absorber and the pneumatic unit to prevent humidity caused by the absorbtion of CO_2.

Gas analyzers

After the zero valve and Nafion tube, the gas passes through the TPX and OM units. The oxygen sensor has two inputs. One input accepts the main flow and the other draws in room air for reference. Both gas flows exit from a single port.

---

[1] 1) Nafion is a trademark of Perma Pure Inc.

Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across an OM inlet restrictor and calculates sample flow from the pressure difference.

Working pressure transducer

The working pressure transducer measures absolute working pressure between the TPX unit and OM unit. It is used for messages: 'sample line blocked', 'check D-fend', 'replace D-fend' and 'check sample gas outlet'.

Pneumatic unit

The pneumatic unit contains a zeroing valve, occlusion valve and tubing connections. There is a series of restrictors and chambers forming a pneumatic filter to prevent pressure oscillations from the pump to reach the measuring units. The occlusion valve connection to room air includes a dust filter and the zero valve connection to room air includes an absorber.

Connection block

The connection block contains a sample gas outlet connector and an OM unit reference gas inlet. The inlet is equipped with a dust filter.

Occlusion valve

The valve is activated, when the sampling line gets occluded. The main flow is then diverted to the side flow of the D-fend water trap to faster remove the occlusion.

Sampling pump and damping chamber

The gas sampling pump is a membrane pump that is run by a brushless DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow, even when the D-fend water trap ages and starts to get occluded. It also enables use of sample tubes with varying lengths and diameters.

The damping chamber is used to even out the pulsating flow and silence the exhaust flow.

NOTE: In no occasion is the flow reversed towards patient.

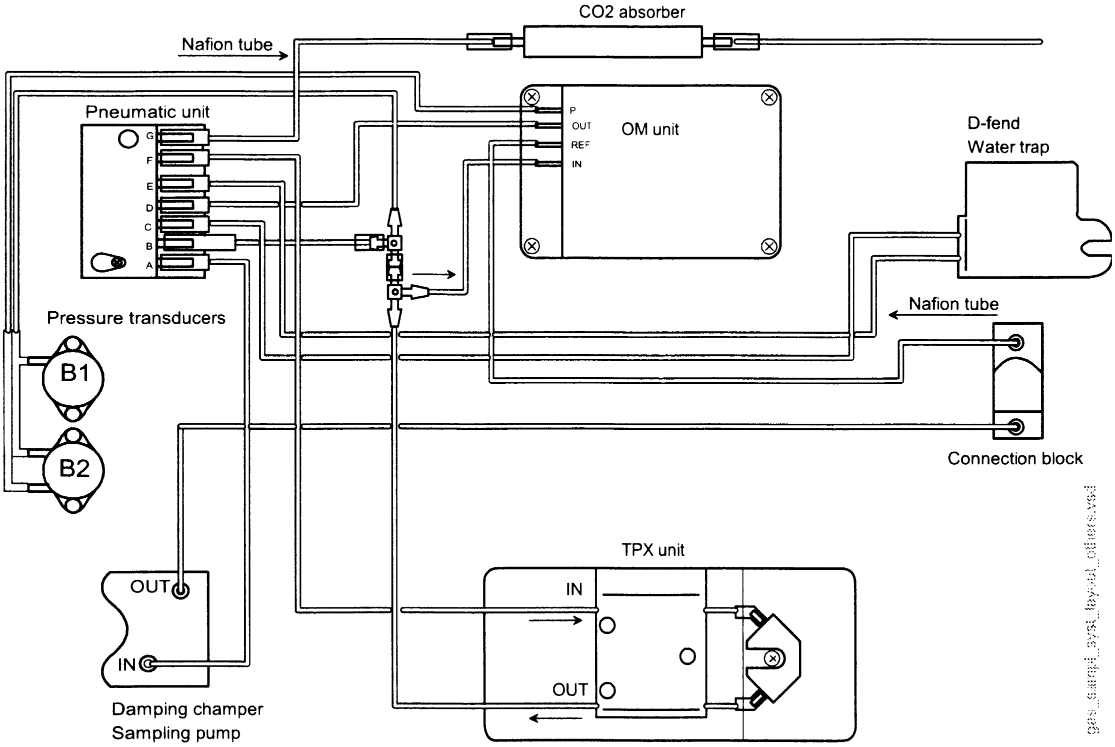
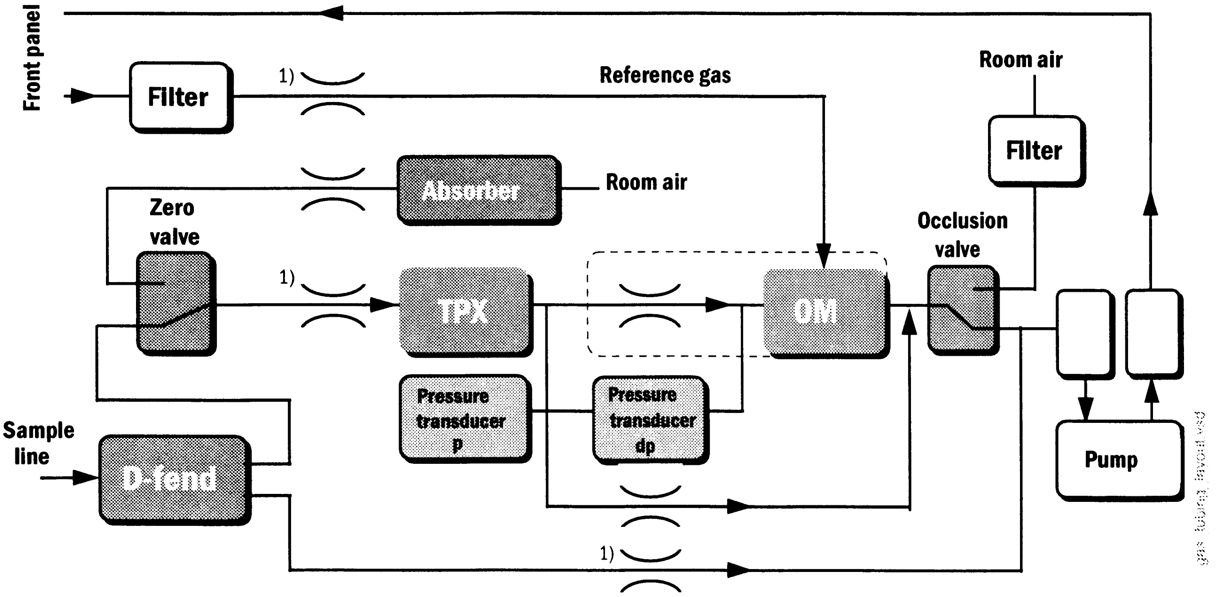

CO2 absorber
Nafion tube
Pneumatic unit
G
F
E
D
C
B
A
P
OUT
REF
IN
OM unit
D-fend
Water trap
Nafion tube
Pressure transducers
B1
B2
Connection block
TPX unit
IN
OUT
OUT
IN
Damping champer
Sampling pump

Figure 6 Gas sampling system layout, E-CAiOV, E-CAiOVX, E-CAiO, E-COVX, E-COV, E-CO


Front panel
Filter
1)
Reference gas
Room air
Filter
Absorber
Room air
Zero
valve
Occlusion
valve
1)
TPX
OM
Pressure
transducer
p
Pressure
transducer
dp
Sample
line
D-fend
Pump
1)

Tubing marked with 1) is thinner in E-CAiOVX and E-COVX module.

Figure 7 Gas tubing layout

2.2.2 TPX measuring unit

The TPX unit is a non dispersive infrared analyzer, measuring absorption of the gas sample at seven infrared wavelengths, which are selected using optical narrow band filters. The IR lamp is a 4 W filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 4 mm length.

From the sample chamber, radiation goes into seven tubular light guides with reflective inner surfaces. At the other end of each light guide, there is a thermopile detector with an optical filter in front of it.

The Temp sensor measures the TPX units' temperature and it is used for temperature compensation.

The TPX unit includes a TPX board located at the end of the unit. Its function is to connect the 7 thermopile signals and the temperature sensor signal to the CPU board.

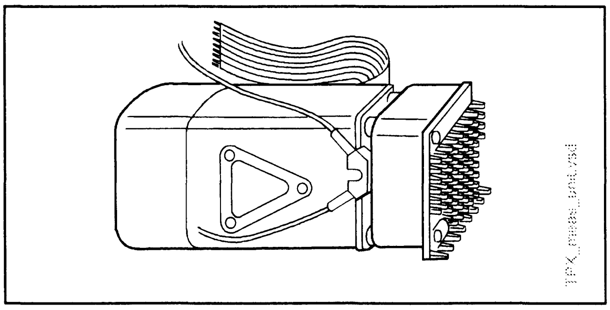


Figure 8 TPX measuring unit

OM measuring unit

The oxygen measurement is based on paramagnetic susceptibility. The gas and the reference gas, which usually is room air, are conducted into a gap in an electromagnet with a strong magnetic field switched on and off at a frequency of approximately 165 Hz.

An alternating differential pressure is generated between the sample and reference inputs due to forces acting to the oxygen molecules in a magnetic field gradient.

The pressure is measured with a sensitive differential transducer, rectified with a synchronous detector and amplified to produce a DC voltage proportional to the oxygen partial pressure difference of the two gases.

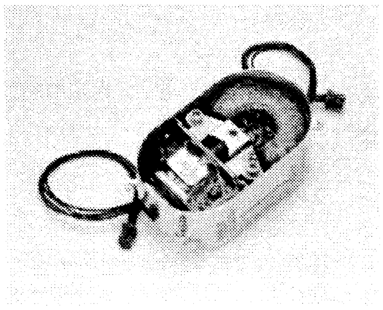


Figure 9 OM measuring unit

2.2.3 PVX measuring unit

NOTE: Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Differential pressure max 25 cmH_2O on one port at a time e.g. when connecting tubes.

When Patient Spirometry is used, a special sensor, D-lite, replaces the normal airway adapter in the patient circuit. A double lumen tubing is attached to the two connectors on the adapter and on the module front panel.

The Patient Spirometry provides patient respiration monitoring capabilities using the D-lite and Pedi-lite flow sensors.

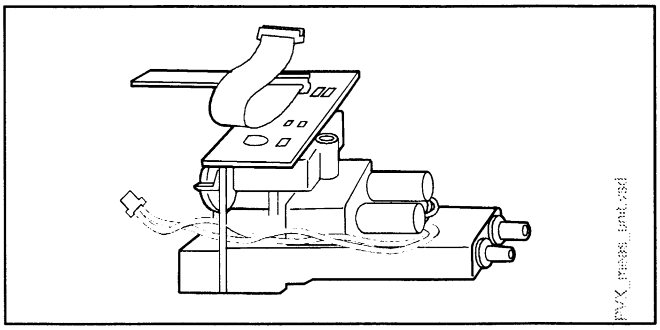


Figure 10 PVX measuring unit

The measurement is based on measuring the kinetic gas pressure and is performed using the Pitot effect. A pressure transducer is used to measure the Pitot pressure. The signal is then linearized and corrected according to the density of the gas. Speed of the flow is calculated from the pressure and TV is integrated from it.

Patient Spirometry consists of airway connections, two pressure transducers, valves and preamplifiers. The preamplifiers are connected to the A/D-converter on the module main CPU.

The breathing flow of a patient passing through the D-lite adapter creates a pressure difference. This pressure difference is measured by a pressure transducer, B1. Overpressure and negative pressure in airways are measured by another pressure transducer, B2.

Gas exchange

The gas exchange measurement uses the concentrations measured by the TPX measurement unit and the O_2 measurement unit, in combination with the flow from the PVX measurement unit. The gas exchange calculation is done by software.

CAUTION The gas exchange measurement in the E-CAiOVX and E-COVX modules works accurately only with 2-meter gas sampling lines.

2.2.4 CPU board

The CPU board contains the processor and memories and A/D-converters that are common to the whole module. The CPU board also contains preamplifiers of TPX-sensor and drivers for valves, fan, pump and lamp. The module is connected to the module bus through an RS-485 serial channel.

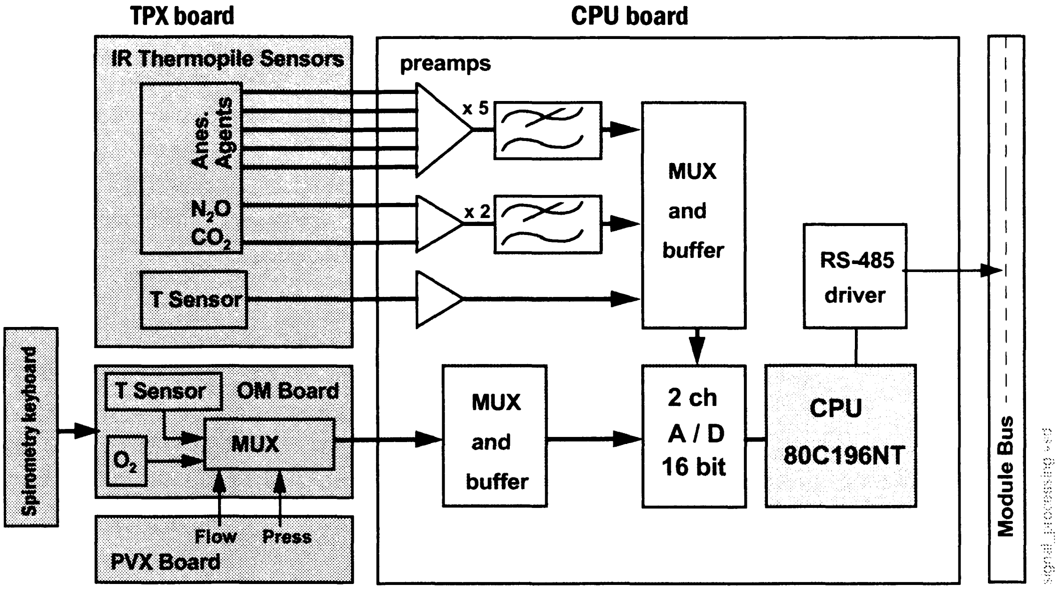

TPX board
CPU board
IR Thermopile Sensors
Anes. Agents
N_2O
CO_2
T Sensor
preamps
x 5
x 2
MUX and buffer
RS-485 driver
Spirometry keyboard
T Sensor
OM Board
O_2
MUX
MUX and buffer
2 ch A / D 16 bit
CPU 80C196NT
Flow
Press
PVX Board
Module Bus

Figure 11 Signal processing

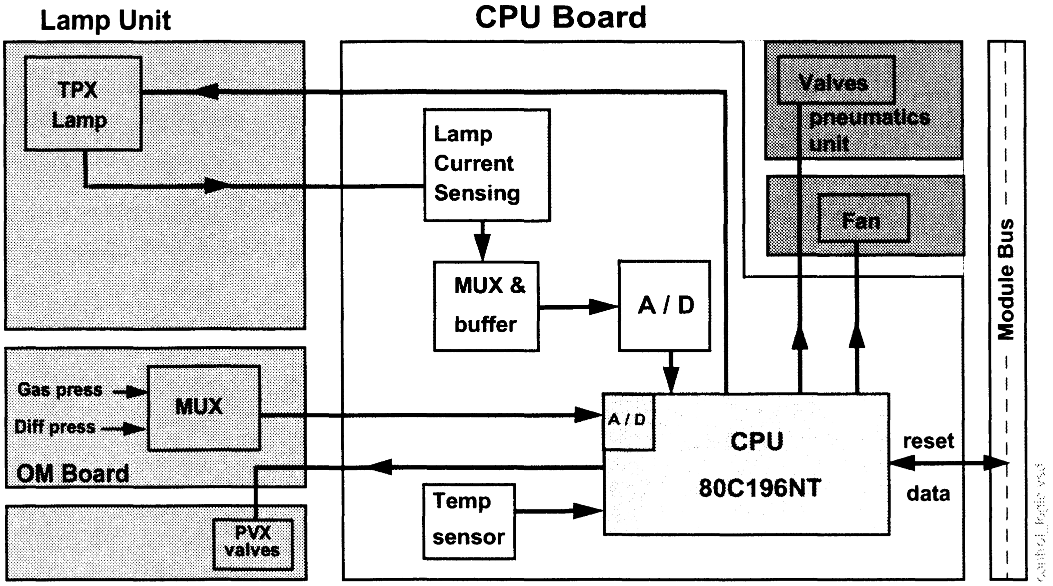

Lamp Unit
CPU Board
TPX Lamp
Lamp Current Sensing
Valves pneumatics unit
Fan
MUX & buffer
A / D
Gas press
Diff press
MUX
OM Board
A / D
CPU 80C196NT
reset
data
Temp sensor
PVX valves
Module Bus

Figure 12 Control logic

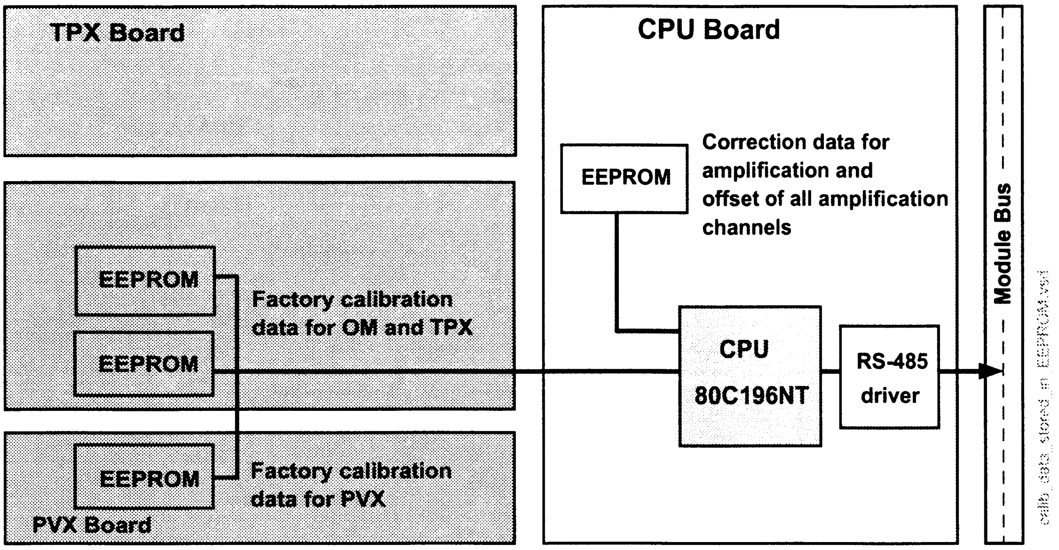

TPX Board
CPU Board
EEPROM
Correction data for amplification and offset of all amplification channels
Module Bus
EEPROM
EEPROM
Factory calibration data for OM and TPX
CPU
80C196NT
RS-485 driver
EEPROM
Factory calibration data for PVX
PVX Board
calib_data_stored_in_EEPROM.vsd

Figure 13 Calibration data stored in EEPROM

2.2.5 OM board

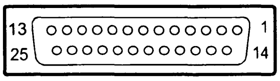
The Oxygen board contains the specific electronics for the oxygen sensor. Sample flow measurement and sampling system pressure sensors are on this board. It also contains EEPROMs that store calibration data of both TPX and OM sensors. The spirometry keyboard connection is on this board.

PVX board

The Spirometry board is connected to the oxygen board. It contains pressure sensors for airway pressure and flow measurement differential pressure and preamplifiers for those. Calibration data of spirometry is stored on its own EEPROM.

2.3 Connectors and signals

2.3.1 Module bus connector pin description

Module bus connector	**Pin No.**	**I/O**	**Signal**
	1	I	RESET RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15VDC
	5	I/O	-DATA RS485
	6	I/O	DATA RS485
	7		Ground and Shield
	8	I	-RESET RS485
	9		n/c
	10		n/c
	11		n/c
	12		n/c
	13		Ground and Shield
	14	I	+24/+32 VDIRTY depends on power supply (not used)
	15	I	Ground DIRTY
	16		n/c
	17		n/c
	18		n/c
	19		n/c
	20	I	GASFR (not used)
	21	I	CTSD (not used)
	22	I	TXDD (not used)
	23	O	RXDD (not used)
	24	I	+5 VDC
	25	I	+5 VDC DIRTY, for infrared lamps

3 Service procedures

3.1 General service information

The field service of the compact airway modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.1.1 OM measuring unit

CAUTION Due to the complicated and sensitive mechanical construction of the O_2 measuring unit, no repairs should be attempted inside the unit.

3.1.2 TPX measuring unit

CAUTION The TPX photometer and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.

3.1.3 OM, TPX, and PVX measuring unit

CAUTION The OM, TPX, and PVX measuring units can be repaired only at the factory.

3.1.4 Serviceable parts

- Absorber
- D-fend
- Nafion tubes
- Fan filter
- Fan
- CPU board
- CPU software
- PVX Unit including PVX board
- Pump

NOTE: After any component replacement, see chapter 3.4. Adjustments and calibrations.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Screwdriver		
Ambient pressure manometer		
Flowmeter		
Flow cassette 50/1.1	873812	
Extra silicon tubing		
Calibration gas and regulator	755583 (gas) 755534	for E-CAiOVX/E-CAiOV/E-CAiO
Calibration gas and regulator	755587 (gas) 755534	for E-COVX
Calibration gas and regulator	755581 (gas) 755534	for E-COV/E-CO
Gas Interface Cable 2.5 m / 8 ft	884299	
Spirometry tester	884202	

NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required, see "Calibration gas regulator flow check" page 30.

3.2.2 Recommended parts

Part	**Order No.**	**Notes**
Absorber	895933	
D-fend	876446	
D-fend+	881319	for E-COVX
Sampling line 3 m/10 ft	73319	anesthesia gas sampling line
Sampling line 2 m/7 ft	73318	for E-CAiOVX/E-COVX
D-lite / Pedi-lite	733950/73393	
D-lite+		for condensing active humidification circuits

Part	Order No.	Notes
Spirometry tube 2 m	890031	
Spirometry tube 3 m	884101	
D-fend O-ring (2 pcs)	65312	
Filter (3 pcs)	886136	1 pcs @ latest revisions
Filter assembly	896025	@ latest revisions
Nafion tubes (2 pcs)	733382	
Fan filter	886236	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - the front cover grounding pins are not bent against the CPU board
   - there are no loose objects inside the module

NOTE: The tubes that are connected to the Oxygen board pressure transducers should not be pressed too deep.

NOTE: Make sure that tubes are not in contact with the sampling pump or the O_2 sensor, or its springs.

✍

2. External parts

   Check that:
   - the front cover and the front panel stickers are intact
   - all connectors are intact and attached properly
   - the D-fend latch is moving properly
   - the module box and latch are intact

✍

3.2.4 Functional inspection

3. Fan filter

   Clean or replace the fan filter.

4. D-fend O-rings

   Detach the D-fend. Check the condition of the rubber O-rings on the metal D-fend connectors, located in the Compact Airway Module front cover.

   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

NOTE: The O-rings are recommended to be replaced annually.

5. Other filters

   Check that flow of air through the filters in the reference gas connection block (1 pc) and in the pneumatic unit (1 or 2 pcs) is not obstructed.

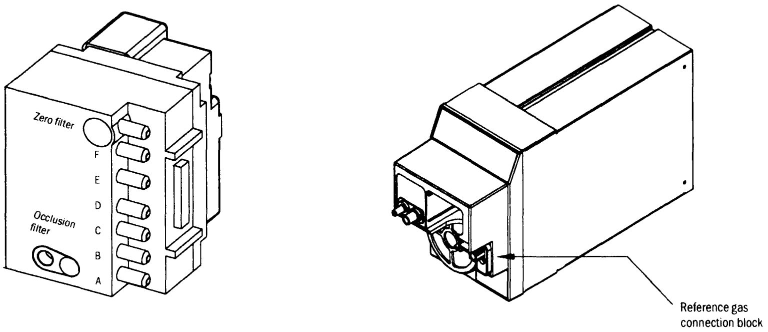


Figure 14 Pneumatic unit and reference gas connection block

NOTE: The filters should be replaced annually.

Replace the old D-fend and sampling line with new ones.

NOTE: Use only GE Healthcare sampling lines in order to ensure proper function.
2 m/7 ft. sampling line should be used with E-COVX and E-CAiOVX.

Connect the Compact Airway Module to the Central Unit's Module motherboard using the Gas interface cable (the grounding plates of the cable should be removed).

Turn the monitor on.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup* - *Waveform fields* - *Field 1* - *Paw***
Field 2* - *Flow
Field 3* - *Off
Field 4* - *O2
Field 5* - *AA

Field 6 - CO2
Digit Fields
Lower Field 1 - Gases

Preset the following gas measurement settings (if available):

Airway Gas - ***Select Agent - Hal***
Spirometry Setup - Scaling Vol
Paw Scale - 20
Flow Scale - 15

6. Fan

   Check that the fan is running.

   ✍

7. Module software

   Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the ***Service*** menu.

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding Compact Airway Module software.

   ✍

8. Module configuration

   Enter the Compact Airway Module service menu.

   Parameters - Gas Unit - General

   Check that the shown module configuration corresponds with the used Compact Airway Module type.

   ✍

9. Module bus communication

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second.

   If one of the values is increasing faster, it indicates a failure in module bus communication.

   ✍

10. Flow measurement offset

    Enter the service menu ***Gases***:

    Gas Unit - Gases

    Check that the flow measurement offset, i.e. the shown sample Zero value is within ±10 ml/min.

    ✍

11. Ambient pressure

    Check that the shown Ambient value corresponds with the current ambient pressure (±20 mmHg).

12. Zero valve

    Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The CO_2 (N_2O, AA) reading should drop back near 0%, the O_2 reading near 21%.

13. Special tubes

    Perform the steam test for the Nafion tubes, or replace those by new.

    Replace the CO_2 absorber, if necessary.

NOTE: The Nafion tubes are recommended to be replaced annually. In case of exchanging the absorber, it is recommended to replace also the Nafion tube.

NOTE: The CO_2 absorber is recommended to be replaced once in four years.

14. Leak test

    Perform sampling system leak test.

    Prevent the module from performing the normal occlusion functions, i.e. controlling the valves, by turning the pump first off, then on again from the menu.

    Block the reference gas connector at the front panel.

    Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the Amb-Work value in the service menu. When the value exceeds 170 mmHg, connect the other port of the flow cassette to the sample gas out connector and switch the pump off.

    Wait until pressure inside the sampling system is stabilized, then notice the shown Amb-Work value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in one minute.

    If the pressure drops more, first ensure the made connections and repeat the test.

15. Flow rates

    Wait until the Sample Flow value is back near 200 ml/min.

    Connect a flowmeter to the 3 meter sampling line (use a 2 meter sampling line for E-CAiOVX and E-COVX) and check that the flow (the flowmeter reading) is within the following range:

Sampling flow (ml/min)	180...220

If necessary, readjust the sampling flow:

Select ***Sample gain adj*** from the menu. To increase the sampling flow, turn the ComWheel counterclockwise, to decrease the flow, turn the ComWheel clockwise.

A change of 0.050 in the Gain value changes the flow approximately 10 ml/min.

After you have changed the gain, wait until the Sample Flow value on the screen gets back near the original, then check the flowmeter reading again.

Connect the flowmeter to the reference gas connector, check that the flow is within the following range:

Reference flow (ml/min)	E-CAiOVX/E-COVX	Others
	27...40 (with 2m sampling line)	31...45 (with 3m sampling line)

Activate the zero valve on from the service menu. The Sample Flow value should not change more than 20 ml/min. If the absorber is connected, the value is 30 ml/min.

16. Working pressure

    Check that the Amb-Work value in the service menu is within the following range:

	E-CAiOVX/E-COVX	Others
Amb-Work (mmHg)	70...115	40...75

17. Gas calibration

    Perform the gas calibration.

    Airway Gas - ***Gas Calibration***

NOTE: Calibration is not recommended until 30 minutes warm-up time has elapsed.

Use calibration gas 755587 (5% CO_2, 95% O_2) for calibrating Airway Module, E-COVX, and calibration gas 755583 (2% Desflurane, 5% CO_2, 33% N_2O, 55% O_2, balance N_2) for E-CAiOVX/E-CAiOV/E-CAiO, and calibration gas 755581 (5% CO_2, 40% N_2O, 55% O_2) for calibrating E-COV/E-CO.

NOTE: You can calibrate the modules E-CO and E-COV with the same calibration gas as the E-COVX module.

NOTE: For correct measurement values, modules need different amounts of oxygen in the calibration mixture. Use only recommended calibration gases to guarantee a successful calibration.

18. Fall time measurement

    Perform the fall time measurement in the ***Gases*** service menu.

    Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters - Gas Unit - Gases***

    Activate the measurement by selecting ***Fall Time Meas*** from the service menu. Feed calibration gas until the message 'Feed' near the fall time values changes to 'READY'. If necessary, repeat the same procedure to get all the values on the screen.

Check that the measured values are within the following ranges:

CO_2 fall time < 400 ms

O_2 fall time < 400 ms

CO_2-O_2 delay < 800 ms

✍

Anesthesia Agent measurement

19. ID unrel.

Agent ID reliability.

Feed calibration gas (order code 755583) continuously for at least 30 seconds and check that the ID in the service menu shows DES and that the value for ID unrel. is lower than 50.

If the value is higher, repeat the gas calibration and check the value again.

✍

Patient Spirometry measurement

20. Spirometry system leak test

Enter the service menu ***Spirometry***:

Gas Unit - Spirometry

Connect a clean Spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a Luer stopper.

NOTE: Make sure that the date marking on the D-lite is 10/94 or newer.

Take the D-lite into your hand and occlude both ends tightly with your fingers (or with both hands). Pressing creates a pressure inside the D-lite. Check that pressure near 5 cmH_2O is generated (the Aw Pressure value in the service menu).

If the system leaks heavily, no pressure will be generated.

If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform (and the Aw Pressure value) decreases slowly and the flow waveform (the Flow value) either goes above, or below the zero line, depending on which of the connectors is leaking.

In case of leakage, first check all the connections and try again.

✍

21. Flow waveform

Remove the blockage from the sampling line port and connect the sampling line. Breathe through the wider side of the D-lite. Check that the flow waveform moves downwards when you breathe in, and upwards when you breathe out.

✍

22. Spirometry tester

    If possible, check the Side Stream Spirometry measurement also with the Spirometry Tester (order code 884202). Follow the instructions that are supplied with the tester.

    ✍

All modules

Turn the monitor off, disconnect the Gas interface cable and reassemble the module. Remember to attach the plastic cover against the CPU board before installing the module box.

NOTE: When reassembling the module, make sure that the tubes are not pinched between the module box and internal parts.

23. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

Install the Compact Airway Module into the Central Unit, turn the monitor on and wait until the message ‘Calibrating gas sensor’ disappears from the screen.

24. Occlusion detection

    Block the tip of the sampling line by your finger and check that the message ‘Sample line blocked’ appears on the monitor screen within 60 seconds.

    ✍

25. Air leak detection

    Detach the D-fend and check that the message ‘Check D-fend’ appears on the monitor screen within 30 seconds.

    ✍

Reattach the D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.

26. Apnea detection

    Check that the monitor shows the message ‘Apnea’ within 30 seconds after you have stopped feeding gas.

    ✍

27. Final cleaning

    Turn the monitor off, disconnect and clean the module.

    ✍

- Fill in all necessary documents.

3.3 Disassembly and reassembly

To disassemble the compact airway module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. Press the release latch. Pull the module box slowly backwards and remove it from the main body.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

Always perform the "Service check" after reassembling the module.

3.3.1 PVX unit

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from CPU board.
4. Disconnect the OM unit's cables, spirometry keyboard cable and PVX unit's cables from the OM board.
5. Detach the front panel from the module chassis (1 screw).
6. Detach the PVX unit from the front panel (1 screw).

To reassemble the module, reverse the order of the disassembly steps.

3.3.2 Pump unit

1. Remove the module box.
2. Cut off the pump's clamp (panduit).
3. Unplug the hoses of the pump.
4. Disconnect the pump's cable from the CPU board. Pass the cable under the pneumatic unit by lifting it.

To reassemble the module, reverse the order of the disassembly steps.

3.3.3 CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).
3. Disconnect the pump cable, pneumatics unit cable, fan cable, and both cables of the TPX unit from the CPU board.
4. Detach the CPU board from the OM board.

To reassemble the module, reverse the order of the disassembly steps.

3.3.4 Software of CPU board

1. Remove the module box.
2. Detach the CPU board and OM board from the module chassis (4 screws).

3. Disconnect the pump cable, pneumatics unit cable, fan cable, and the other cable of the TPX unit from the CPU board.
4. Detach the CPU board from the OM board.
5. Detach the software from the CPU board.

To reassemble the module, reverse the order of the disassembly steps.

3.3.5 Instructions after replacing software or CPU board

After replacing the software or CPU board:

- perform the sampling system leak test
- perform the occlusion test
- perform the gas calibration
- perform the fall time measurement

3.4 Adjustments and calibrations

See "User's Reference Manual" for normal gas calibration instructions.

3.4.1 Gas sampling system adjustment

NOTE: Let the monitor run for 15 minutes before measuring flow rates.

For the flow rate measurements, a flowmeter with a low flow resistance and capability to measure low flow rates is required. A sampling line of normal length has to be connected to the monitor as it has a considerable effect on the flow.

3.4.2 Flow rate measurement

If any flow rates are not correct, first replace the D-fend water trap. Then recheck the incorrect flows.

The sampling flow rate is measured by a rotameter at the sampling line. The rate should be between 180 and 220 ml/min. The flow rate is adjusted in the ***Gases*** service menu with ***Sample gain adj***.

The reference flow of the oxygen measuring unit is checked as follows:

Connect the rotameter to the Gas Ref. inlet on the front panel. The flow rate should be between 31 and 45 ml/min (E-CAiOVX/E-COVX: 27-40 ml/min). The flow rate is not adjustable.

3.4.3 Flow rate adjustment

NOTE: Before adjusting the sampling flow, make sure there is no leakage in the sampling system.

Refer to chapter 3.2. Service check, step 15; "Flow rates".

3.4.4 Gas calibration

NOTE: Ensure that the calibration gas and the regulator are functioning properly before calibration. Perform annual maintenance on the regulator as required.

The gas calibration is performed in the ***Airway Gas*** menu.

Calibration gas regulator flow check

Interval: every 12 months

Regulator flow specification:

REF 755533 & 755534: 260 - 410 ml/min at 1-10 bar cylinder pressure
REF 755530: 260 - 410ml/min at 5-7psi cylinder pressure

Tools needed: calibration gas can, regulator, piece of silicon hose and flow meter. GE Healthcare recommends use of TSI 4140 Flow Meter.

Insert the calibration gas regulator on the gas cylinder. Connect a silicon hose between the regulator and the flow meter. Block the regulator overflow port and open the regulator. Check the flow rate from the flow meter and verify that the flow is within the specification.

Flow calibration

The PVX measuring unit is calibrated at the factory and due to the unit's design, calibration is not regularly needed. The calibration data is saved into the board's EEPROM. In case calibration is needed, it is recommended to perform the calibration both with adult values using the D-lite, and with pediatric values using the Pedi-lite.

1. Connect a spirometry tube with a D-lite sensor to the compact airway module. To improve the accuracy, the endotracheal tube and all accessories which normally are in use should be attached also during the calibration.
2. Enter the ***Gas Unit*** service menu: **Monitor Setup** - ***Install Service*** - ***Service*** - ***Parameters***. Enter the ***Spirometry*** menu.
3. After the flow is zeroed ('Zero OK' message displayed), attach a spirometry tester to the flow sensor (D-lite or Pedi-lite). Select the sensor type.
4. Perform the calibration according to the tester instructions. Observe the values of inspired and expired tidal volumes.
5. Adjust the reading to match the calibration volume (about 1000 ml for the D-lite and 300 ml for the Pedi-lite). Adjust ***Exp Flow Gain*** and ***Insp Flow Gain*** values in proportion to the difference between the measured values and the spirometry tester reading.

4 Troubleshooting

4.1 Troubleshooting charts

Problem	**Cause / What to do**
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. See the gas sampling system troubleshooting.
'SENSOR INOP.' message	The temperature is too high, check fan and filter at the front panel. Communication error, check timeout and bad checksum values at the service menu.
'xx ZEROING ERROR' message	Gas zeroing failed. Condensation or residual gases are affecting zero measurement. Allow module to run drawing room air for half an hour and calibrate again.
'CHECK D-FEND' message ('Air leak' message)[1a)]	Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage.
'REPLACE D-FEND' message ('Replace water trap' message)[1)]	Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend.
'REBREATHING' message ('FiCO$_2$ high' message)[1)]	CO$_2$ concentration in inspiratory air is too high. Possibly CO$_2$ absorber in ventilation is saturated. Change the ventilation absorber.
'SAMPLE LINE BLOCKED' message ('Air leak' message)[1)]	Sampling line or water trap is occluded. Water trap container is full. If occlusion persists, check internal tubing for blockages.
('SELECT AGENT' message)[1)]	No anesthetic agent is selected though delivery is started. Vaporizer valve is broken, or traces of cleaning or disinfecting agent in the water trap container affecting the readouts. Let the container dry properly after disinfection before use.
No response to any gas	Sampling line, water trap, or internal tubing blocked or loose, or improperly attached. Occlusion or zero valve malfunction. Pump failure. Supply voltage missing. Serial communication error.
Sudden increase in gas display	Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
Abnormally high response to all gases (or abnormally low) or sudden occlusion warning	Pressure transducer failure.

Problem	**Cause / What to do**
Strong drift in all gases	Leak in sampling line or internal tubing (especially in conjunction with too low readings).
'MVexp << MVinsp' message	Leak in patient circuit between patient and D-lite, or in the patient lungs, or leak in tubes from D-lite to module. Check D-lite connection and D-lite tubing.
(Disconnection)1b) (MVexp < 0.5 l/min message)1) Low volumes	Too small tidal volumes for accurate measurement (not shown during Apnea). Gas sampling is working correctly. Check D-lite connections and D-lite tubing.

a. 1) @ earlier monitor software versions

b. 1) @ earlier monitor software versions

4.1.1 CO$_2$ measurement

Problem	**Possible clinical cause**	**Possible technical cause**	**What to do**
too low ETCO$_2$ value	- sudden decrease in circulation - pulmonary embolism - hyperventilation - very large dead-space - large shunting	- leak in sampling system - calibration error - high by-pass flow from ventilator	- check all connections - check calibration
too high ETCO$_2$	- hypoventilation - increased metabolism	- D-fend contaminated - calibration error	- change D-fend - check calibration
waveform clipped		- incorrect scaling	- change scale
no response to breathing	- apnea - (disconnection)1)	- sampling line or water trap loose or blocked (air leak)1)	- check all connections
		- sample gas outlet blocked	- check that outlet is open
ETCO$_2$ overscale >15% (>20%)1) Shown until 32%, specified range 0...15%	- abnormally high ETCO$_2$ (permissive hypercapnia)	- CO$_2$ sensor contaminated - D-fend malfunction	- call service technician - change D-fend
ETCO$_2$>PaCO$_2$	- unit is mmHg or kPa and ETCO$_2$ is close to arterial PCO$_2$	- Dry gas as default	- change to Wet gas by using ***Install/Service*** menu

4.1.2 Patient spirometry

Problem	Possible clinical cause	Possible technical cause	What to do
insp TV>exp TV	• leak in lungs • ET tube cuff leak	• spirometry tube leak • water inside D-lite or tubings • another side stream gas sampling between D-lite and patient • D-fend leaks	• check leakages -- perform leak test • change tubings and D-lite • do not use active humidification 2 connect gas sampling only and always to D-lite 2 check D-fend
exp TV> insp TV		• spirometry tube leak • water inside D-lite or tubings	• check leakages -- perform leak test • change tubings and D-lite • do not use active humidification
loop overscale monitored volumes < set volumes		• wrong scale selected • leak between ventilator and D-lite	• change scaling • check ventilator connections
strongly vibrating loop too large or too small volumes	• mucus in ET tube	• - • water or secretions in hoses or D-lite • wrong mode vs. sensor selection • incompatible between selected sensor and sensor used	• suction the patient • change dry D-lite and/or empty the water from hoses • check mode and sensor - D-lite for adult - Pedi-lite for pediatric

Problem	Possible clinical cause	Possible technical cause	What to do
fluctuating Raw	• mucus in airways or tubings • breathing effort against the ventilator • patient triggered breaths	• ventilator exp. valve causes fluctuations during exp. flow	
too high Raw	• kink in tubing • mucus • asthmatic patient • bronchospasm • spontaneous breaths • breathing efforts against the ventilator • patient triggered breaths		
Raw value invalid			
too high Ppeak	• bronchospasm • patient is coughing • patient breaths against the ventilator • obstruction in airways • HME obstructed	• CO_2 measurement is not connected • stat PEEPi measurement not selected 1a) • exp. pause did not last at least 4 sec.	• connect CO_2 meas. to D-lite • go to spirometry setup 1)
static PEEPi not measured			
Compl value invalid	• spontaneous breaths		

a. 1) only @ earlier monitor software versions

4.1.3 Gas exchange

Problem	Possible clinical cause	Possible technical cause	What to do
"Strange" values	• ventilation mode: BiPaP, CPAP with high continuous by-pass flow • presence of N_2O or anesthetic agents in ICU applications		• gas exchange not measurable • do not use N_2O or AA in ICU, or use a E-CAiOVX module
Unphysiological VO_2 readings	• unstable O_2 delivery - gas mixer		• select oxygram and verify the stableness of the curve
	• RR over 35/min	• reference gas inlet port blocked	• check reference port
		• gas sampling line longer than 2 m	• change 2 m sampling line
		• dead space of Y-piece > 8 ml	• check the dead space of Y-piece
		• gas sampling line connected to HME	• gas sampling line should ALWAYS be connected to D-lite
		• D-lite incorrectly placed	• do not connect anything between D-lite and Y-piece • ALWAYS connect D-lite between the HME and Y-piece
VO_2 value invalid, no VO_2, $FiO_2 > 85\%$, $(FiO_2+FiN_2O) > 85\%$	• over range • no VO_2 value • 999 ml/min $< VO_2 < 0$		

4.2 Gas sampling system troubleshooting

Faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt or other matter accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and if necessary, adjust the flow rate.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: The D-fend water trap should be replaced when the 'REPLACE D-FEND' message appears during monitor startup.

NOTE: If any liquid has entered the TPX measuring unit due to water trap filter failure, contact GE Healthcare Technical Services.

4.2.1 Sampling system leak test

1. Prevent the module from performing the normal occlusion functions, i.e. controlling the valves, by turning the pump first off, then on again from the menu.
2. Block the reference gas connector at the front panel.
3. Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the Amb-Work value in the service menu. When the value exceeds 170 mmHg, connect the other port of the flow cassette to the sample gas out connector and switch the pump off.
4. Wait until the pressure inside the sampling system is stabilized, then notice the shown Amb-Work value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in one minute.
5. If the pressure drops more, first ensure the connections you have made and repeat the test.

4.2.2 Steam test for the Nafion™ tubes

Choose Halothane as anesthetic agent and let the monitor sample room air. Then quickly feed air of 100% relative humidity (for instance from a kettle in which you are boiling water) to the monitor. If the digital reading jumps as much as 0.1%, replace the Nafion tubes.

4.3 OM measuring unit troubleshooting

CAUTION Due to the complicated and sensitive mechanical construction of the oxygen measuring unit, no repairs should be attempted inside the unit. Instead, if the fault has been found in the measuring unit itself, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

In cases of no response to O_2 or strong drift, check the tubing for loose connections, blockages and leaks.

CAUTION Never apply overpressure to the O_2 measuring unit, as the pressure transducer may be permanently damaged.

If the O_2 signal is noisy, check the measurement unit suspension.

4.4 TPX measuring unit troubleshooting

CAUTION The TPX measuring unit can only be repaired and calibrated at the factory. In case of failure, the entire module should be replaced and the faulty module be sent to GE Healthcare for repair.

4.5 PVX measuring unit troubleshooting

In case of failure, the PVX unit can be replaced.

NOTE: Never apply overpressure or negative pressure of more than 300 cmH_2O to the flow and volume tubing. Also never apply differential pressure of more than 25 mmHg on one PVX connection at a time.

4.5.1 Spirometry tubing leak test

1. Select airway pressure (Paw) and flow waveforms (Flow) on the monitor screen.
2. Connect a clean spirometry tube to the module and a clean D-lite to the other end of the tube. Block the D-lite's sampling line port, for example with a luer stopper.

NOTE: Make sure that the date marking on the D-lite is 10/94 or newer.

3. Take the D-lite in your hand and occlude both ends tightly with your fingers (or with both hands). Pressing firmly with the fingers creates a pressure inside the D-lite.
4. Check that a pressure of at least 5 cmH_2O is generated. If the system leaks heavily, no pressure will be generated. If there is a small leak in the connections, the monitor will measure a pressure difference which is then interpreted as flow and seen on the monitor screen. The pressure waveform decreases slowly and the flow waveform either goes above, or below the zero line, depending on which of the connectors is leaking.

4.6 CPU board troubleshooting

Due to the complexity of the large scale integrated circuitry, there are few faults in the CPU digital electronics that can be located without special equipment.

Check only that RAM, EPROM, CPU, and other socketed ICs are properly installed.

4.7 Error messages

Message	**Cause**
Occlusion or Sample Line Blocked	The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear.
Continuous occlusion. Check sampling line and D-fend.	Occlusion over 40 seconds.
Check D-Fend	-the water trap is not connected -there is a leak in the sampling line inside the module. If air leak persists, measured gas values disappear.
Air leak detected. Check water trap and sample gas out-flow. Press normal screen to continue.	Air leak over 40 seconds.
Replace D-fend (replace water trap)1)	Indicates residue build-up on the water trap membrane. This decreases air flow.
Gas calibration is not available during the first 5 minutes/during occlusion/during air leak	Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak.

Message	**Cause**
Gas out blocked	- Gas out connector on the front panel, or the exhaust line connected to it, is blocked. - If the sample gas is returned to patient circuit, the filter in the return kit may be occluded. - Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure.
Select agent1a)	No agent selected.
Select agent1)	Mixture of agent is detected, but no agent is selected.
Check agent1)	Agent is selected manually, but it differs from the identified one.
Failure in Agent ID (unknown agent)	The agent ID has failed (due to a third agent).
Overrange	FiO_2 >100% measured.
Recalibration	Time out, fluctivating gases, gain adjusted “over”.
C02, 02, AA, N20	
Zero error	Unsuccessful zeroing.
Unstable, Calibr error	Unsuccessful calibration.
Menu messages during calibration:	
Zero error	Unsuccessful zeroing.
Adjust	Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration.
Unstable	Unsuccessful calibration.

a. 1) only @ earlier monitor software versions

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} Compact Airway Modules, E-CAiOVX, E-CAiOV, E-CAiO, E-COVX, E-COV or E-CO.

APPENDIX A Service check form, Compact Airway Modules

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Fan filter	☐	☐	☐	4. D-fend O-rings	☐	☐	☐
5. Other filters	☐	☐	☐				
Notes							
6. Fan	☐	☐	☐				
7. Module software	GAS						
8. Module configuration	☐	☐	☐	9. Module bus communication	☐	☐	☐
10. Flow measurement offset					±10 ml/min		
11. Ambient pressure	☐	☐	☐	12. Zero valve	☐	☐	☐
13. Special tubes	☐	☐	☐				
14. Leak test					≤6 mmHg/min		
Notes							

15. Flow rates	Measured value	Allowed range
Sampling flow (E-CAiOVX/E-COVX)		180...220 ml/min
Reference flow (E-CAiOVX/E-COVX)		27...40 ml/min
Reference flow (E-CAiOVX/E-COVX)		27...40 ml/min
Reference flow (others)		31...45 ml/min
Zeroing flow		±20 ml/min
16. Working pressure	Measured value	Allowed range
Amb-Work		40...75 ml/min
Amb-Work (E-CAiOVX/E-COVX)		70...115 ml/min
Notes		

	OK	N.A.	Fail		
17. Gas calibration	☐	☐	☐		

18. Fall time measurement	Measured value	Allowed range
CO2 fall time		< 400 ms
O2 fall time		< 400 ms
CO2-N2O delay		< 800 ms

AA option		S/N
19. ID unrel.		< 50

Patient spirometry option				S/N			
	OK	N.A.	Fail		OK	N.A.	Fail
20. Spirometry system leak test	☐	☐	☐	21. Flow waveform	☐	☐	☐
22. Spirometry tester	☐	☐	☐				
Notes							

All modules	OK	N.A.	Fail		OK	N.A.	Fail
23. Electrical safety check	☐	☐	☐	24. Occlusion detection	☐	☐	☐
25. Air leak detection	☐	☐	☐	26. Apnea detection	☐	☐	☐
27. Final cleaning	☐	☐	☐				

Notes

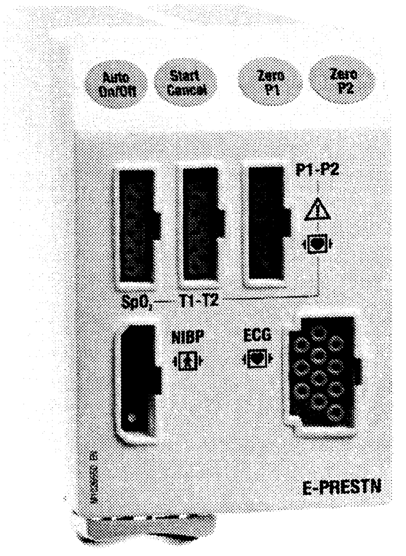
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Hemodynamic Modules, E-PRESTN, E-RESTN, E-PRETN (Rev. 00)

Technical Reference Manual


Auto On/Off
Start Cancel
Zero P1
Zero P2
P1-P2
SpO₂
T1-T2
NIBP
ECG
E-PRESTN

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027824
June, 2005

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Appendix A: Service check form,
Hemodynamic Module, E-PRESTN, E-RESTN, E-PRETN (Rev. 00) A-1

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Introduction

This Technical Reference Manual Slot provides information for the maintenance and service of the hemodynamic modules S/5 E-PRESTN/-RESTN/-PRETN. The modules are double width modules designed for use with S/5 monitors. Later in this manual modules may be referred to without S/5 for simplicity.

Please also refer to "Technical Reference Manual" of the monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The E-PRESTN/-RESTN/-PRETN modules provide general hemodynamic parameters.

NOTE: Do not use identical modules in the same monitor simultaneously. All the following modules are considered identical:

E-PRESTN/ -RESTN/ -PRETN,
E-PSM(P)

M-PRESTN/ -RESTN/ -PRETN,
M-NE(12)STPR/ -NE(12)STR/ -NE(12)TPR,
M-ESTPR/ -ESTR/ -ETPR,
M-ESTP/-EST/-ETP

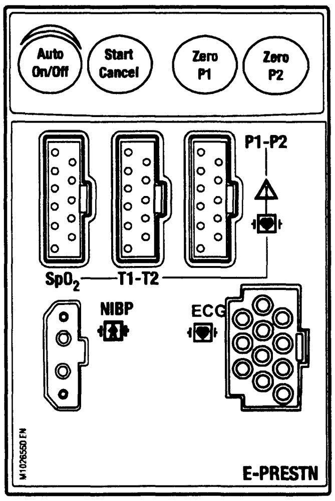


Figure 1 **S/5 Hemodynamic Module, E-PRESTN**

Table 1 **Options of S/5 Hemodynamic modules**

	Parameter	**PRESTN**	**RESTN**	**PRETN**
P	Two invasive blood pressures	x		x
R	Impedance respiration	x	x	x
E	ECG	x	x	x
S	Pulse oximetry	x	x	
T	Two temperatures	x	x	x
N	NIBP	x	x	x

NOTE: 12-lead ECG measurement requires Display Controller, B-DISP or B-DISPX.

Intended purpose (Indications for use)

The Datex-Ohmeda PRESTN module (model family E-PRESTN) and accessories are indicated for the monitoring of hemodynamic parameters of all hospital patients. The hemodynamic parameters of the module comprise ECG including ST-segment and arrhythmia, Impedance respiration, NIBP, Temperature, SpO2 (including monitoring during conditions of clinical patient motion), and invasive blood pressure.

Impedance respiration measurement is indicated for patients aged 3 and up. The NIBP measurement is indicated for patients who weigh 5kg (11 lb.) and up. This device is indicated for use by qualified medical personnel only.

Monitor software compatibility

Datex-Ohmeda E-PRESTN Rev. 00 module is designed for use with Datex-Ohmeda monitors using software as follows:
AM: L-ANE04(A) or later versions
CCM: L-ICU04(A) or later versions
CAM: L-CANE04(A) or later versions
CCCM: L-CICU04(A) or later versions

Equipment safety symbols

⚠	When displayed on the E-PRESTN, E-PRETN, E-RESTN module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO_2), temperature (T) and invasive pressure (P) measurement

1 Specifications

1.1 General specifications

Module size W x D x H	75 x 186 x 112 mm 3.0 x 7.3 x 4.4 in
Module weight	0.7 kg / 1.5 lb.
Power consumption	about 6 W
Operation temperature	10 to 40°C / 50 to 104°F

1.2 Typical performance

1.2.1 NIBP

NOTE: Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)

Oscillometric measurement principle.

Measurement range	adult	25 to 260 mmHg
	child	25 to 195 mmHg
	infant	15 to 145 mmHg
Pulse rate range accepted	30 to 250 bpm	
Measurement interval	from 1 min. to 4h	
Typical measuring time	adult	23 s
	infant	20 s
Initial inflation pressure	adult	170 ±10 mmHg
	child	150 ±10 mmHg
	infant	120 ±10 mmHg
Venous stasis	adult	40 ±5 mmHg / 2 min.
	child	40 ±5 mmHg / 2 min.
	infant	30 ±5 mmHg / 1 min.
Cuff widths	see User's Guide	

1.2.2 ECG

Lead selection	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6
Sweep speeds	12.5, 25, 50 mm/sec.

Display filter

Diagnostic	0.05 to 150 Hz
Monitoring	0.5 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.5 to 40 Hz (-3 dB, with 60 Hz reject filter)
ST filter	0.05 to 30 Hz (-3 dB, with 50 Hz reject filter) 0.05 to 40 Hz (-3 dB, with 60 Hz reject filter)

Heart rate from ECG

Range	30 to 250 bpm
Accuracy	±5 bpm or ±5%, whichever is greater
Resolution	1 bpm
Update interval	5 s
Averaging time	5 s

ST levels (in main software)

ST level range	-9 to +9 mm (-0.9 to +0.9 mV)
Resolution	0.1 mm (0.01 mV)
Averaging	calculated from 8 QRS

Pacemaker pulse detection

Detection level	2 to 700 mV
Pulse duration	0.5 to 2 ms

The monitor is specified for both of the methods A and B in ANSI/AAMI EC13 4.1.4.2.

Synchronization- signal to the module bus

Direct ECG	analog output of ECG, 1 V/1 mV
Pacer	5 V and 0.5 to 2.5 ms pulse, < 30 ms after pacer peak
Defibrillator	5 V and 10 ms pulse, < 35 ms after R-point synchronization

1.2.3 Pulse oximetry

Measurement range	0 to 100%
Calibration range	70 to 100 %
Accuracy[1]	100 to 70%, ±2 digits ±3 digits during clinical patient motion 69 to 0%, unspecified
Display resolution	1 digit = 1% of SpO_2
Display averaging time	Slow, Normal, beat-to-beat
Pulse beep pitch	varies with SpO_2 level

The monitor is calibrated against functional oxygen saturation SpO_2 func.

Pulse rate from Pleth

Measurement range	30 to 250 bpm
Accuracy	30 to 100, ±5 bpm, 100 to 250, ±5%
Resolution	1 bpm
Display averaging	10 s

Adjustable pulse beep volume.

Pleth waveform

Scales	2, 5, 10, 20, 50 mod%, Auto

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

1.2.4 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C) ±0.2 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.1 °F)
Temperature test	automatic (every 10 min.)

---

[1] Accuracy is based on deep hypoxia studies with volunteered subjects during motion and non-motion conditions over a wide range of arterial blood oxygen saturation as compared to arterial blood CO-Oximetry. Accuracy may depend on the sensor used, please refer to the instructions for use in the accessory package.

Probe type	compatible with YSI 400 and 700 series
Single use sensors	±0.2 °C (25 to 45.0 °C) ±0.3 °C (10 to 24.9 °C)

1.2.5 Invasive blood pressure

Measurement range	-40 to 320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Scales	upper limit is adjustable between 10 and 300 mmHg in steps or 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

Digital display

Range	-40 to 320 mmHg
Resolution	±1 mmHg

Waveform display

Range	-30 to 300 mmHg

Pulse rate from arterial pressure

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5 bpm or ±5% whichever is greater

1.2.6 Respiration

NOTE: The respiration measurement is intended for patients over three years old

Measurement range	4 to 120 breath/min
Accuracy	±5 breath/min or ±5%
Resolution	1 breath/min
Averaging time	30 s
Update interval	10 s

Respiration waveform

Sweep Speeds	6.25 mm/s and 0.625 mm/s

1.3 Technical specifications

1.3.1 NIBP

Deflation rate, PR dep.	3 to 8 mmHg/s	
Inflation time	20 to 185 mmHg, 1 to 5 s	
Automatic software control, max. inflation pressure		
	adult	280 ±10 mmHg
	child	200 ±10 mmHg
	infant	145 ±5 mmHg
Over pressure limit, stops measurement after 2 seconds		
	adult	320 mmHg
	child	220 mmHg
	infant	160 mmHg

The safety circuit limits the maximum cuff pressure to 320 mmHg in adult/child mode or to 160 mmHg in infant mode. Independent timing circuit limits the pressurizing (>15 mmHg) time to 3 minutes maximum in adult/child mode, and to 90 seconds at (>5mmHg) in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, the inflation pressure is increased typically 50 mmHg.

Max. measurement time	adult	120 s
	child	120 s
	infant	75 s

Pressure transducer accuracy is better than ±3 mmHg or ±2% whichever is greater.
Max. error ±4 mmHg.

Protection against electrical shock	Type BF defibrillation proof

1.3.2 ECG

Defibrillation protection	5000 V, 360 J
Recovery time	5 s
Input impedance	>2.5 MΩ (10 Hz)
CMRR	>100 dB (ST)
System noise	<30 mV (p-p, RTI)
Allowable offset	±1VDC
Gain range	0.2 to 5.0 cm/mV
Pacemaker pulse detection	2 to 700 mV, 0.5 to 2 ms pulses
Protection against electrical shock	Type CF defibrillator proof

1.3.3 Pulse oximetry

Protection against electrical shock	Type CF defibrillation proof

1.3.4 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.5 Invasive blood pressure

Digital display averaging

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

Accuracy	±5% or ±2 mmHg, whichever is greater
Transducer and input sensitivity	5 µV/V/mmHg
Filter	0 to 4 - 22 Hz adjustable
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg

Zero time	less than 15 s
Protection against electrical shock	Type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.6 Respiration

Excitation frequency, 12-lead ECG	31.25 kHz
Breath detection	automatic, manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0
Input dynamic range	0.2 to 20 Ω
Input impedance range	100 to 5000 Ω
Respiration Rate	min. 4 breath/min max. 120 breath/min
Lead off detection	>3 MΩ

2 Functional description

2.1 Measurement principle

2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- a multiparameter hemodynamic module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the “User's Guide” or the “User's Reference Manual” for electrodes' positions and other information.

2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 940 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the SpO_2 probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation (SpO_2) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO_2.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths, only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation SaO_2frac;

$$SaO_2frac = \frac{HbO_2}{HbO_2 + Hb + Dyshemoglobin}$$

Formula 1

or against functional saturation SaO_2func;

$$SaO_2func = \frac{HbO_2}{HbO_2 + Hb}$$

Formula 2

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage SpO_2 measured by the Datex-Ohmeda module is calibrated against functional saturation SaO_2func. The advantage of this method is that the accuracy of SpO_2 measurement relative to SaO_2func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

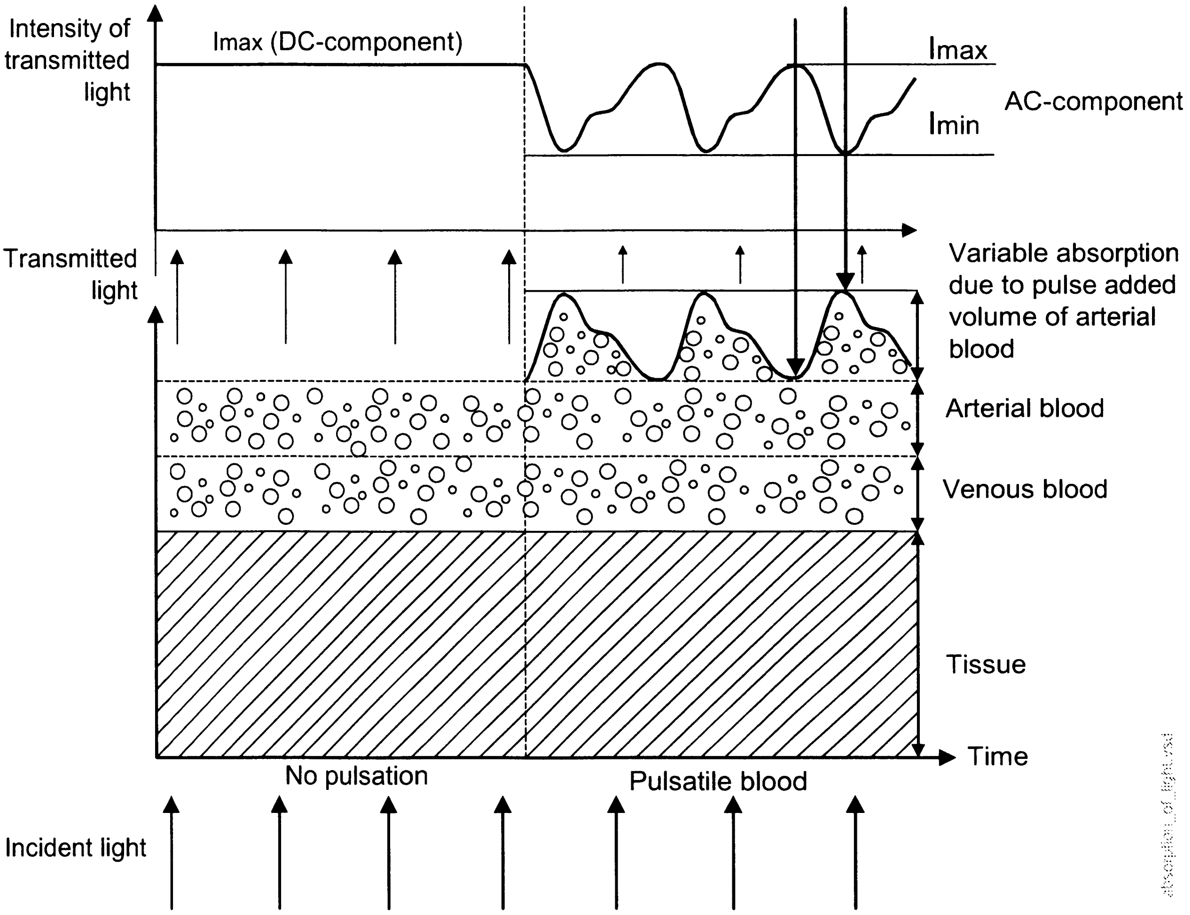

Intensity of transmitted light
Imax (DC-component)
Imax
Imin
AC-component
Transmitted light
Variable absorption due to pulse added volume of arterial blood
Arterial blood
Venous blood
Tissue
Time
No pulsation
Pulsatile blood
Incident light
absorption_of_light.vsd

Figure 2 **Absorption of infrared light in the finger**

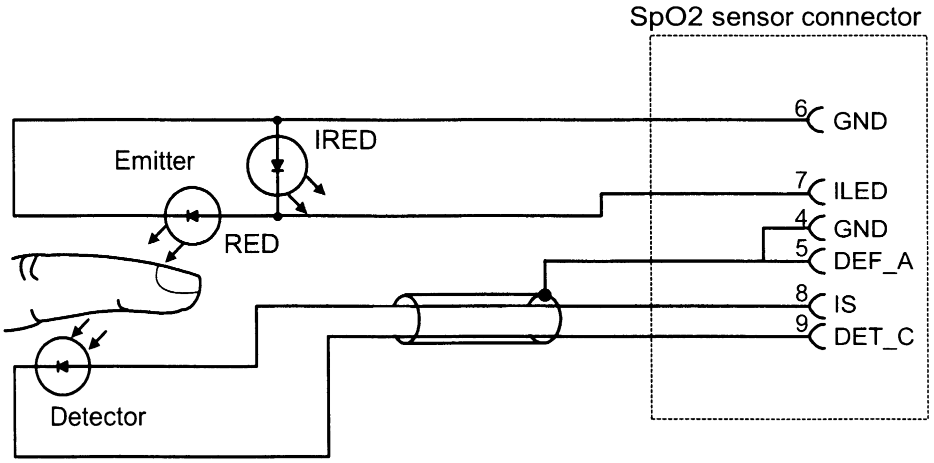

SpO2 sensor connector
Emitter
IRED
RED
Detector
6 GND
7 ILED
4 GND
5 DEF_A
8 IS
9 DET_C

Figure 3 **Pulse oximetry probe parts layout and schematic diagram**

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from GE Healthcare.

2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current through the resistor and measuring the voltage that is generated across it.

In Datex-Ohmeda modules the two methods are combined in the form of a voltage divider. The NTC-resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of a connecting tubing, a pressure transducer, an intravenous bag of normal saline, all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

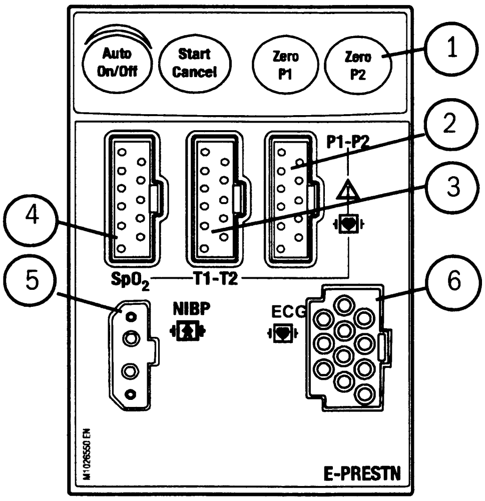
The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. The respiration rate is calculated from these impedance changes, and the respiration waveform is displayed on the screen.

2.2 Main components

2.2.1 E-PRESTN/-RESTN/-PRETN modules



1. Module keys
2. InvBP connector in E-PRESTN, E-PRETN
3. Temperature connector
4. SpO$_2$ connector in E-PRESTN, E-RESTN
5. NIBP connector
6. ECG and impedance respiration connector

Figure 4 Front panel of E-PRESTN

The E-PRESTN, E-RESTN and E-PRETN modules contain three main PC boards, the STP board, the ECG board, and the NIBP board. Each of these boards contain a processor and software in the processor flash memory. The boards produce their own supply voltages from the Vmod 13.8-16 V line that is available via the module bus connector. One exception, the NIBP board provides +5V for the ECG and STP board non-isolated side components. The NIBP board provides also the synchronization signal for the ECG and STP board power supplies.

There are two input boards; the STP input board attached to the front panel of the module and the ECG input board in its own housingThe front panel has five connectors and four keys. There is one connector for two temperature measurements, one for two invasive blood pressure measurements, one for ECG, one for NIBP, and one for SpO$_2$ measurement. The NIBP connector includes two plungers for NIBP hose identification. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero.

2.2.2 NIBP board

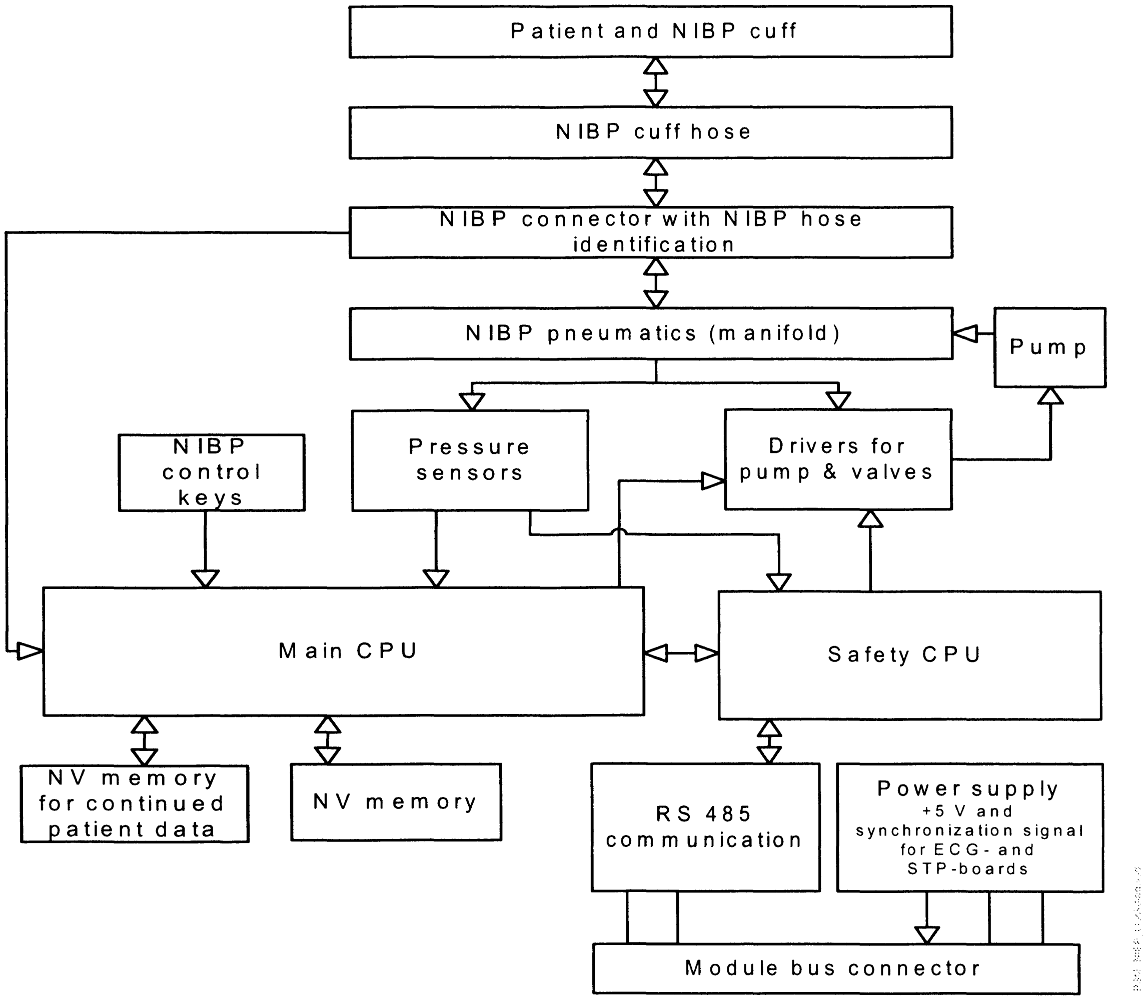

Patient and NIBP cuff
NIBP cuff hose
NIBP connector with NIBP hose identification
NIBP pneumatics (manifold)
Pump
NIBP control keys
Pressure sensors
Drivers for pump & valves
Main CPU
Safety CPU
NV memory for continued patient data
NV memory
RS 485 communication
Power supply
+5 V and synchronization signal for ECG- and STP-boards
Module bus connector

Figure 5 NIBP board functional block diagram

Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with an H8/3052 microprocessor at 16 MHz oscillator frequency.

Memory

The NIBP program memory (processor flash memory) size is 512k x 8. The processor has 4 kBytes RAM and there is also an external RAM memory, the size of which is 128k x 8. Variable values of the NIBP measurement are stored into the external RAM. The EEPROM size is 512 x 8 and it is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and the module serial number.

Software control

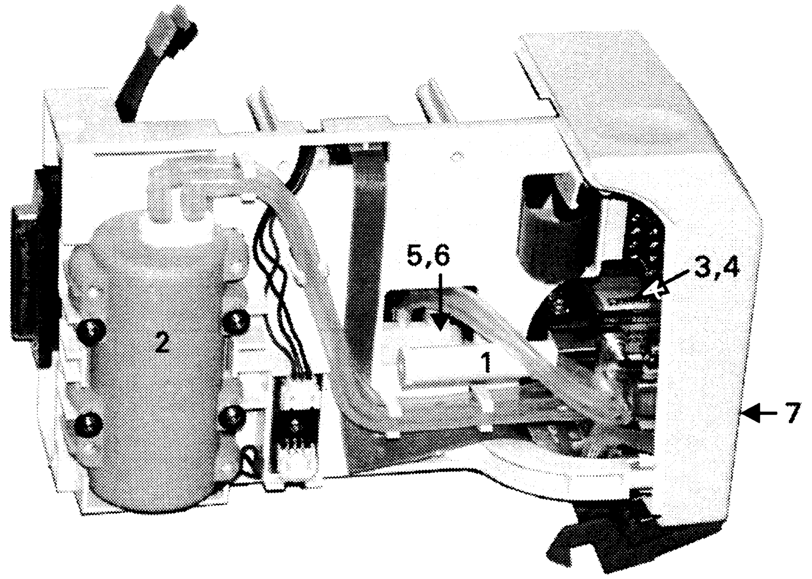
The software controls valves and a pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line, the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: "RS485 communication"

Safety circuit

The NIBP board is equipped with an independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset maximum measurement time, or if the pressure of the cuff is inflated over the specified pressure limit. The maximum measurement time values and pressure limits for different measurement modes have been specified in the technical specification section of this manual.

Pneumatics



The module has the following pneumatics parts:

1. **Intake air filter**; for preventing dust and other parts from entering the air pump and the valves.
2. **Air pump**; for pumping the measuring pressure of the cuff.
3. **(Pulse) Valve**; for producing a linear pressure fall (bleeding) in order to measure the blood pressure of the patient.
   Note that in the service menu also names **Valve** and **Set valve** have been used for this valve.
4. **Safety valve**; The safety valve is intended to be used for deflating the cuff in single fault case, i.e. to prevent too long a measurement time or too high an inflation pressure of the cuff.
   Note that lso **Exh2 valve** has been used to designate the **Safety valve** in service menu.
5. **Main pressure sensor**; for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.
6. **Safety pressure sensor;** for detecting the , cuff loose, cuff occlusion situations, etc. and for recognizing the pressure sensor fault.
7. **Cuff connector;** for connection and hose identification.

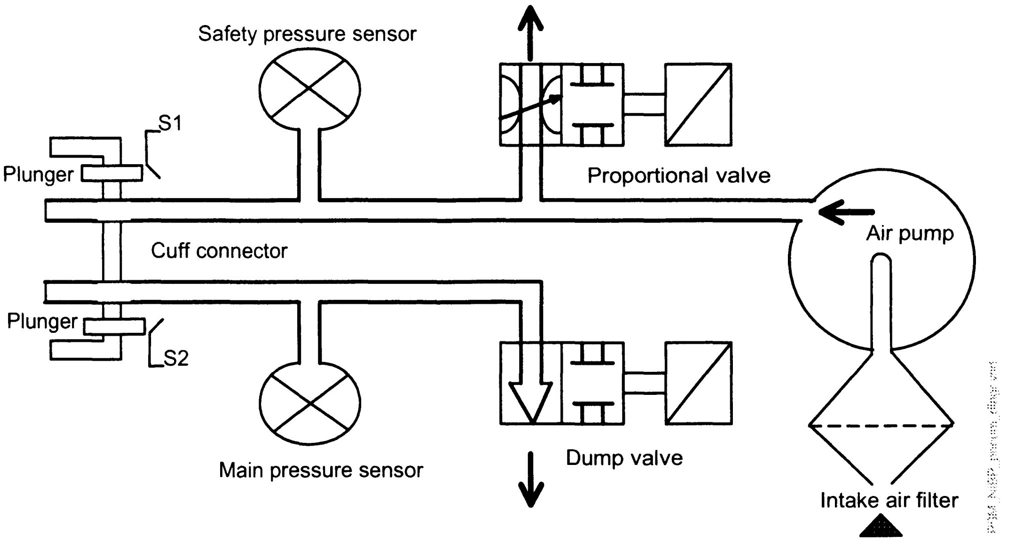

Safety pressure sensor
S1
Plunger
Proportional valve
Air pump
Cuff connector
Plunger
S2
Main pressure sensor
Dump valve
Intake air filter

Figure 6 NIBP pneumatics diagram

Power supply section of the NIBP board

All connections are established via a 25-pin connector (D-type, female). The module needs a +15 V (dirty) power supply to operate. The supply voltage (+15V) is generated in the power supply section of the S/5 monitor. The other voltages needed for the operation of the NIBP measurement are made on the NIBP board.

2.2.3 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the functions shown in Figure 7 on page 16. All functions are located in the ECG board except the ECG input unit.

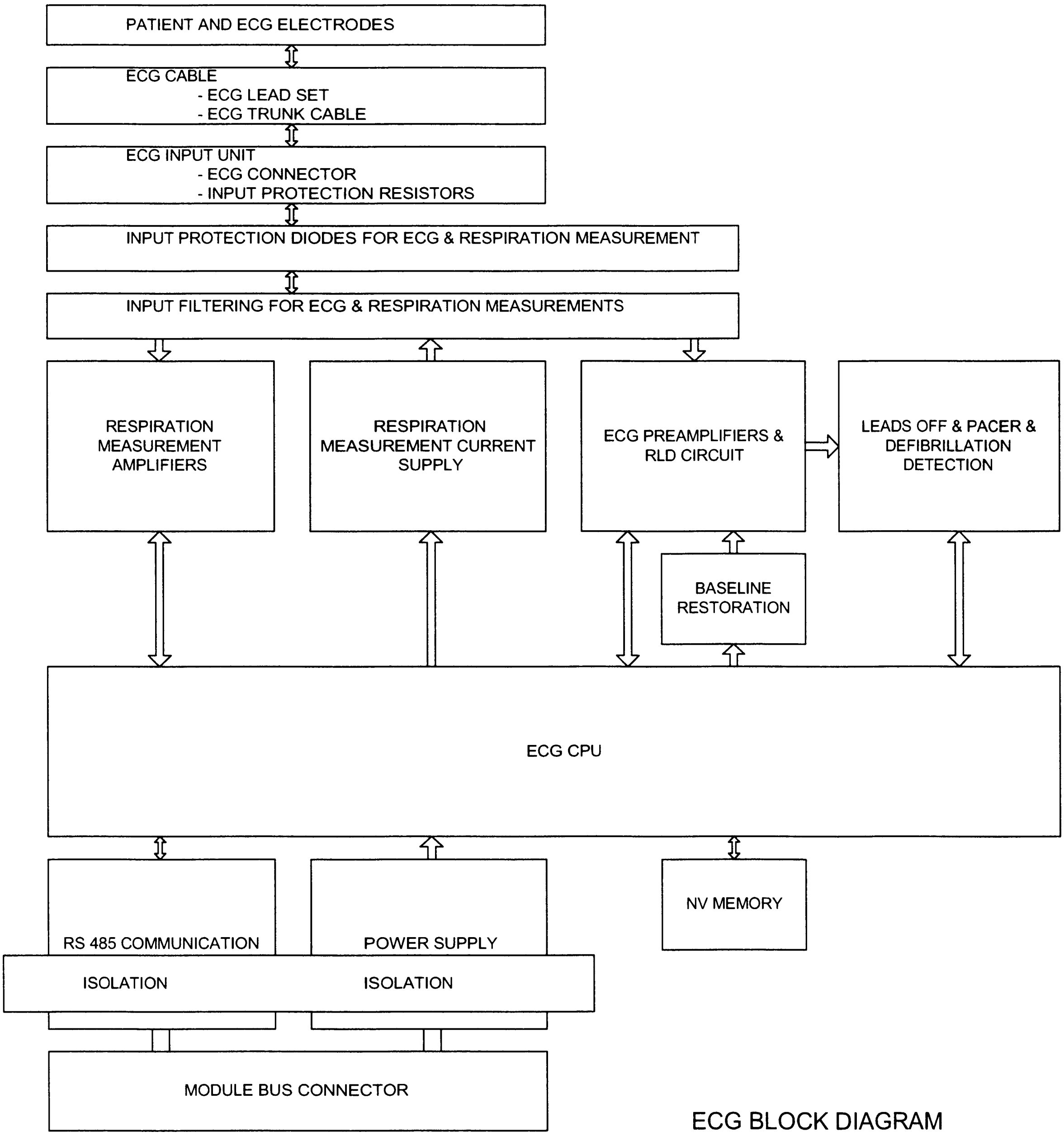

PATIENT AND ECG ELECTRODES
ECG CABLE
- ECG LEAD SET
- ECG TRUNK CABLE
ECG INPUT UNIT
- ECG CONNECTOR
- INPUT PROTECTION RESISTORS
INPUT PROTECTION DIODES FOR ECG & RESPIRATION MEASUREMENT
INPUT FILTERING FOR ECG & RESPIRATION MEASUREMENTS
RESPIRATION MEASUREMENT AMPLIFIERS
RESPIRATION MEASUREMENT CURRENT SUPPLY
ECG PREAMPLIFIERS & RLD CIRCUIT
LEADS OFF & PACER & DEFIBRILLATION DETECTION
BASELINE RESTORATION
ECG CPU
RS 485 COMMUNICATION
POWER SUPPLY
NV MEMORY
ISOLATION
ISOLATION
MODULE BUS CONNECTOR
ECG BLOCK DIAGRAM

Figure 7 **12-lead ECG measurement block diagram**

ECG input unit

The ECG input unit consists of the front panel connector and the ECG input connector board with the high voltage protection resistors. The connector for the 12-lead ECG cable is a green 11-pin rectangle shaped connector.

Input protection and filtering

The input protection is implemented with high voltage protection resistors in the ECG input unit and with protection diodes in the ECG board. The input filtering for ECG measurement is done with passive RC filtering.

ECG preamplifiers

The buffer amplifiers are used for each lead. The "Leads off" detection is implemented by measuring the output level of the input buffer amplifiers with the A/D converter of the CPU. The ECG signals are measured using differential amplifiers.

ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level, e.g. after the change of the DC offset voltage.

Pacer detection

Pacer detection has been made by using four slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently of the ECG measuring channels.

Respiration impedance supply

The 31.25 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. When ECG measurement is 5/12-lead, the respiration measurement is always done between R and F, independently on the ECG lead selection. When ECG measurement is 3-lead, then the respiration measurement is happened at the same lead as the ECG measurement (I, II or III).

ECG CPU

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module.

Power supply

The ECG board has a driver-controlled half-bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

2.2.4 ECG filtering

Datex-Ohmeda S/5 monitors have three ECG filtering modes:

MONITORING	0.5 to 30 Hz (with 50 Hz reject filter) 0.5 to 40 Hz (with 60 Hz reject filter)
DIAGNOSTIC 12-lead ECG	0.05 to 150 Hz
ST FILTER	0.05 to 30 Hz (with 50 Hz reject filter) 0.05 to 40 Hz (with 60 Hz reject filter)

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

The monitor filter is used in normal monitoring. The diagnostic filter is used if more accurate diagnostic information is needed. The ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with software. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly. They are software based filters used for the mains supply filtering. With these filters the 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is 150 Hz and it is limited by software.

2.2.5 STP board

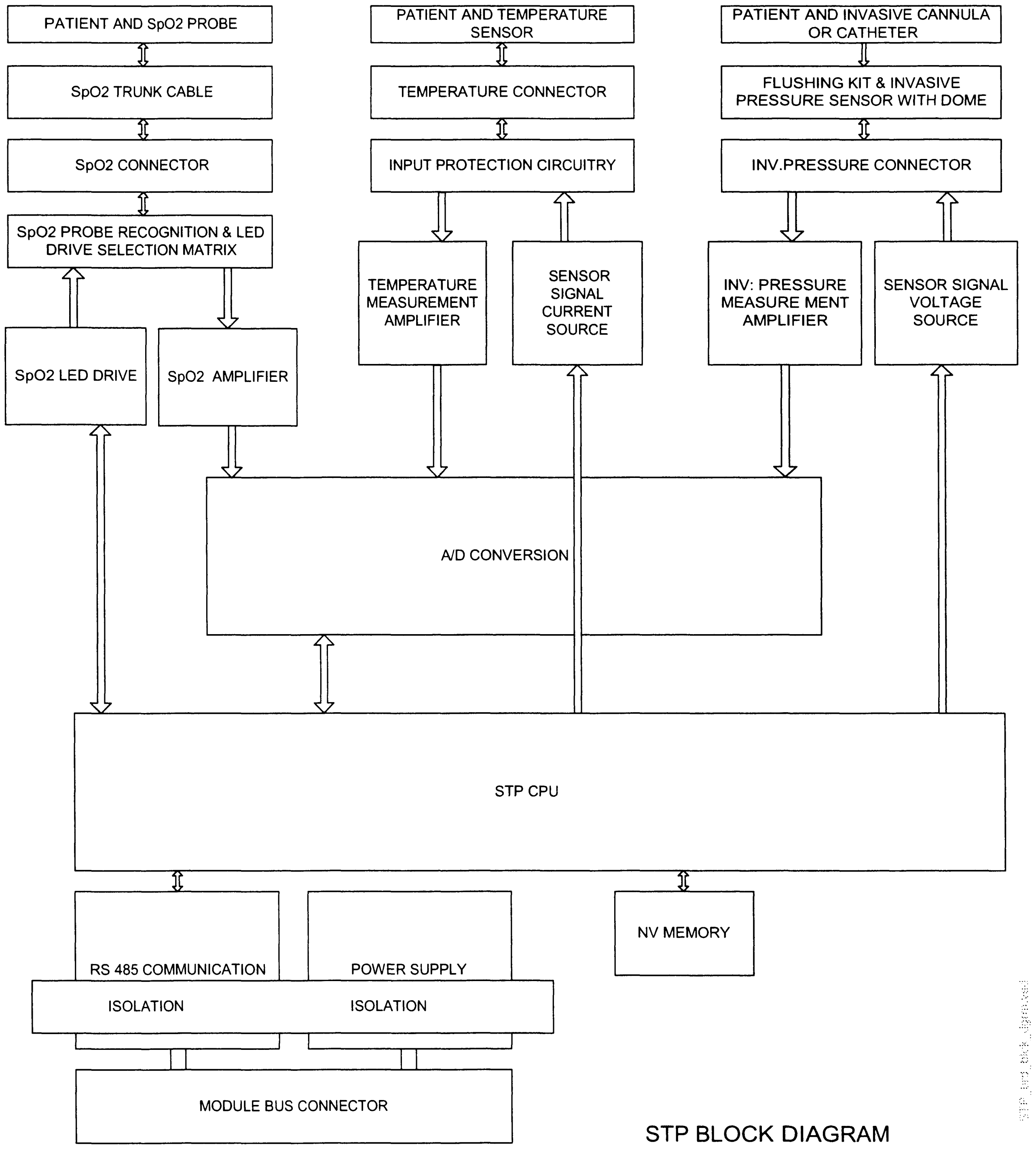

PATIENT AND SpO2 PROBE
SpO2 TRUNK CABLE
SpO2 CONNECTOR
SpO2 PROBE RECOGNITION & LED DRIVE SELECTION MATRIX
SpO2 LED DRIVE
SpO2 AMPLIFIER
PATIENT AND TEMPERATURE SENSOR
TEMPERATURE CONNECTOR
INPUT PROTECTION CIRCUITRY
TEMPERATURE MEASUREMENT AMPLIFIER
SENSOR SIGNAL CURRENT SOURCE
PATIENT AND INVASIVE CANNULA OR CATHETER
FLUSHING KIT & INVASIVE PRESSURE SENSOR WITH DOME
INV.PRESSURE CONNECTOR
INV: PRESSURE MEASURE MENT AMPLIFIER
SENSOR SIGNAL VOLTAGE SOURCE
A/D CONVERSION
STP CPU
RS 485 COMMUNICATION
POWER SUPPLY
ISOLATION
ISOLATION
NV MEMORY
MODULE BUS CONNECTOR
STP BLOCK DIAGRAM
STP_brd_blck_dgrm.vsd

Figure 8 STP board block diagram

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain a pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about 38 μA current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the STP board through an A/D converter.

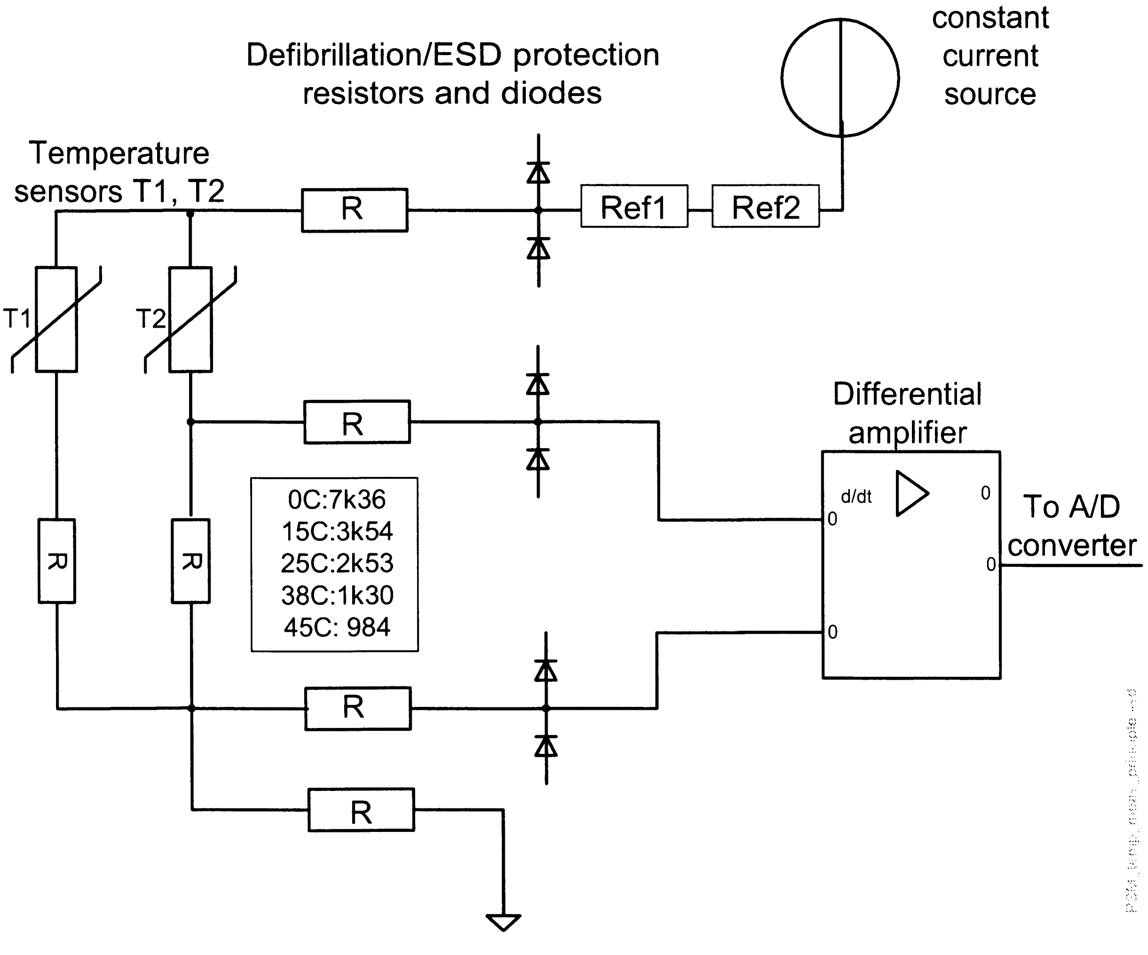

Defibrillation/ESD protection resistors and diodes
constant current source
Temperature sensors T1, T2
R
Ref1
Ref2
T1
T2
R
R
R
R
R
0C:7k36
15C:3k54
25C:2k53
38C:1k30
45C: 984
Differential amplifier
d/dt
0
0
0
0
To A/D converter

Figure 9 **Temperature measurement principle**

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to the A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

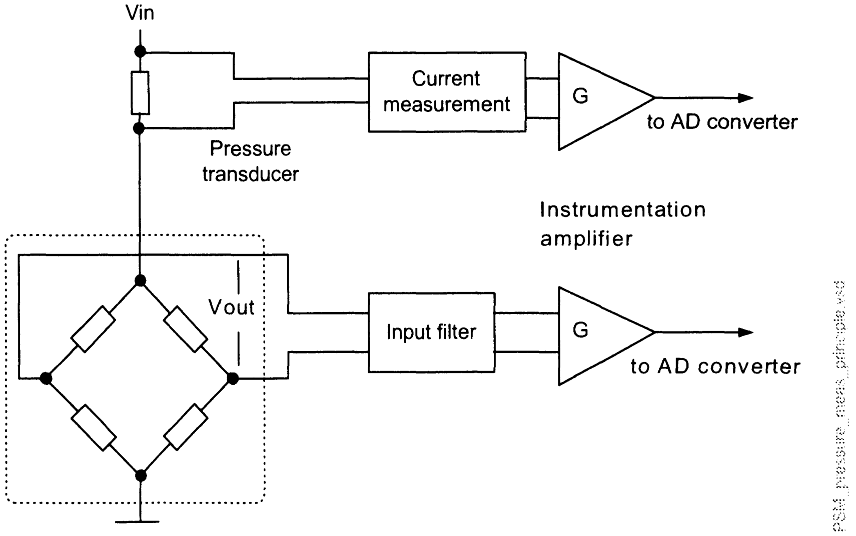


Figure 10 Pressure measurement principle

Pulse oximetry measurement section

LED control signals

The D/A converters of the microcontroller on the STP board set the LED intensity adjustment values for the infrared and red LEDs of the SpO_2 probe. The microcontroller on the STP board switches ON (to the adjusted intensity) and OFF the SpO_2 probe LEDs according to the predetermined sequence.

LED driving circuit

Differential amplifiers measure the LED currents (LED current indication) of the SpO_2 probe over the shunt resistors placed in the LED current paths. The LED driving voltages (LED voltage indication) are measured from the driver circuitry. The LED driving circuits also have MOSFET transistor matrix to enable the use of different probe configurations.

Measured signal preamplification

The preamplifier is a bipolar/single-ended current-to-voltage converter with adjustable gain. A higher gain is used for measuring thin tissue. The preamplification stage has also ambient light reduction and a second amplifier stage.

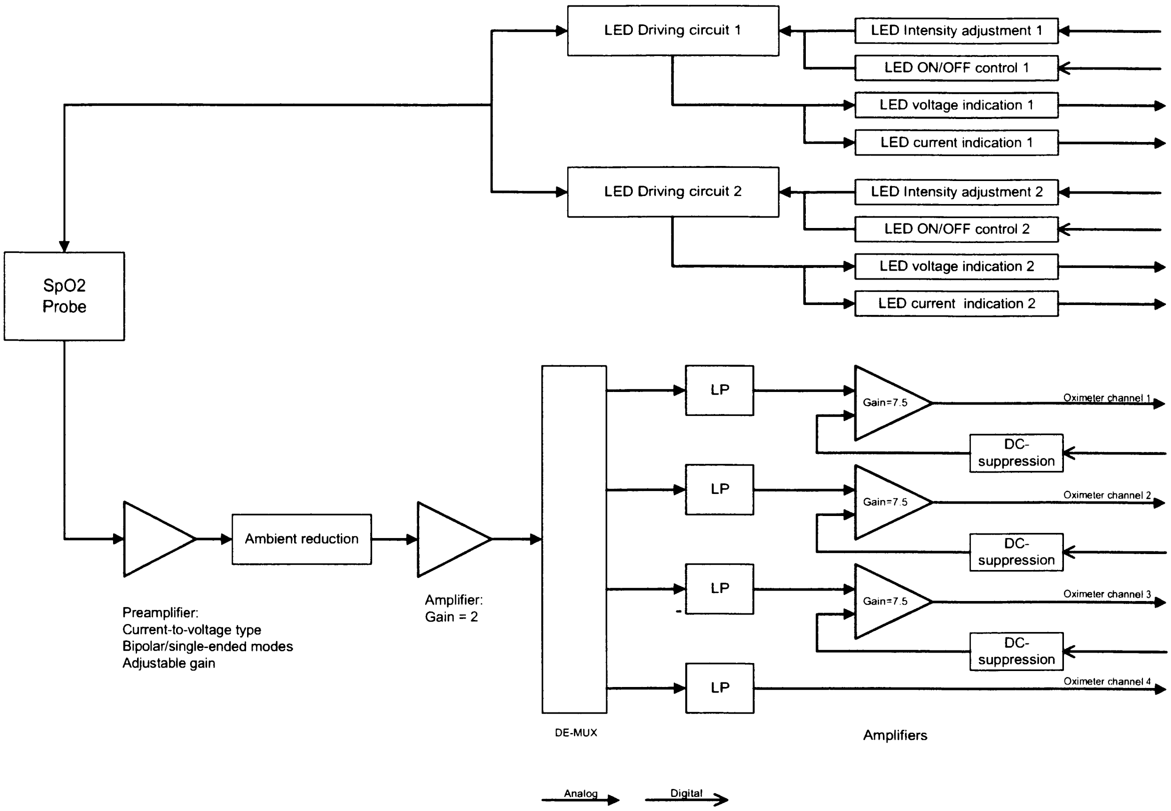

LED Driving circuit 1
LED Intensity adjustment 1
LED ON/OFF control 1
LED voltage indication 1
LED current indication 1
LED Driving circuit 2
LED Intensity adjustment 2
LED ON/OFF control 2
LED voltage indication 2
LED current indication 2
SpO2
Probe
LP
Gain=7.5
Oximeter channel 1
DC-
suppression
LP
Gain=7.5
Oximeter channel 2
DC-
suppression
LP
Gain=7.5
Oximeter channel 3
DC-
suppression
LP
Oximeter channel 4
Ambient reduction
Preamplifier:
Current-to-voltage type
Bipolar/single-ended modes
Adjustable gain
Amplifier:
Gain = 2
DE-MUX
Amplifiers
Analog
Digital

Figure 11 Pulse oximetry measurement block diagram

Red and infrared channel separation

It is possible to multiplex the detector signal to four different channels depending on the content of the signal. The detector signal must at least multiplex into infrared and red signals. Other channels are e.g. for diagnostic purposes.

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. The data transmission rate is 500kbps.

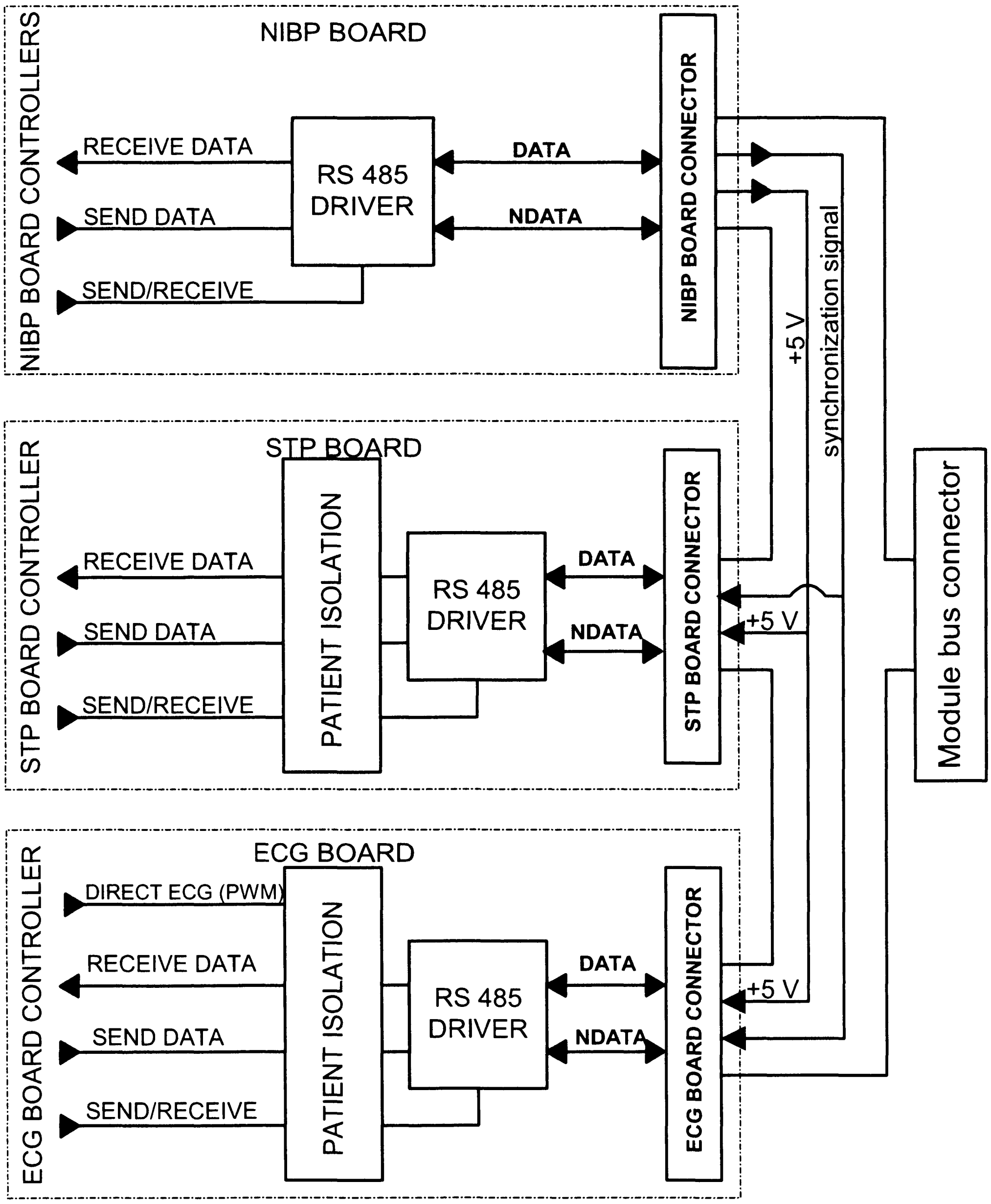

NIBP BOARD CONTROLLERS
NIBP BOARD
RECEIVE DATA
SEND DATA
SEND/RECEIVE
RS 485 DRIVER
DATA
NDATA
NIBP BOARD CONNECTOR
+5 V
synchronization signal
STP BOARD CONTROLLER
STP BOARD
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
STP BOARD CONNECTOR
+5 V
Module bus connector
ECG BOARD CONTROLLER
ECG BOARD
DIRECT ECG (PWM)
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
ECG BOARD CONNECTOR
+5 V

Figure 12 Serial communication of E-PRESTN module

Signals and isolation barrier

The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

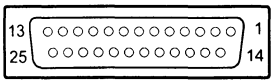
The power for the electronics on the floating part of the STP and the ECG boards is made on each board with the switching power supplies connected to a high voltage isolated transformer. The switching power supplies on the STP and ECG boards are synchronized to the frequency, about 340kHz of the switching power supply on the NIBP board. The NIBP board supplies non-isolated 5 V to the ECG and STP boards. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. Each measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Only the shaded signals of the table below are valid for the PRESTN module

Table 7 Module bus connector description

Module bus connector (X1)	Pin No.	I/O	Signal	Note
	1	I	RESET_RS485	
	2	I	-15 VDC	
	3	I	+15 VDIRTY	
	4	I	+15 VDC	
	5	I/O	NDATA_RS485	
	6	I/O	DATA_RS485	
	7		Ground & Shield	
	8	I	-RESET_RS485	
	9	I	CTSB	
	10	0	RTSB	
	11	I	RXDB	
	12	0	TXDB	
	13		Ground & Shield	
	14	I	+32 VDIRTY	
	15	I	GroundDIRTY	
	16	I	CTSC	
	17	0	RTSC	
	18	I	RXDC	
	19	0	TXDC	
	20		ON/STANDBY	
	21	0	PWM_ECG	
	22		RXDD_RS232	
	23		TXDD_RS232	
	24	I	+5 VDC	
	25	I	+5 VDC	

2.3.2 Front panel connectors

Table 8 ECG connector

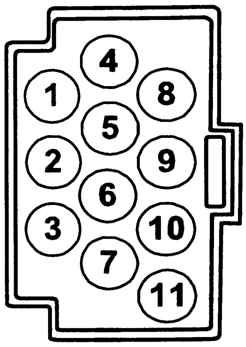
ECG Connector	Pin No.	Signal Name
	1	R/RA; Right arm electrode
	2	C2/V2; Chest electrode
	3	C3/V3; Chest electrode
	4	L/LA; Left arm electrode
	5	N/RL; Neutral/Right Leg Drive electrode
	6	C1/V1; Chest electrode
	7	C4/V4; Chest electrode
	8	F/LL; Left Leg electrode
	9	C6/V6; Chest electrode
	10	C5/V5; Chest electrode
	11	Cable Shield

Table 9 Sp0$_2$ connector

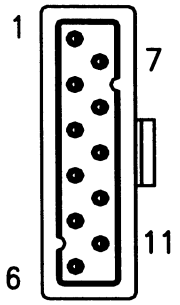
Sp0$_2$ connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	DATA-	
	4	Wire 1/3	LED connection
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	DET_SHIELD	
	8	PRB_ID	Bin/ID Resistor+
	9	Wire 3/5	LED Connection
	10	RED_C	RED LED cathode
	11	DATA+	

Table 10 Invasive blood pressure connectors (P1, P2)

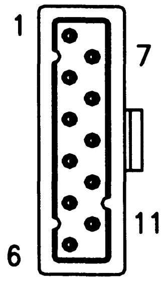
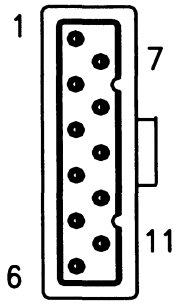
Invasive blood pressure connectors (Dual BP)	Pin No.	Signal	Description
	1	BP_+VREF	BP transducer excitation voltage, channel 1
	2	BP SIG+	BP transducer signal positive (+), channel 1
	3	BP_+VREF	BP transducer excitation voltage, channel 2
	4	AGND	Analog ground
	5	BP SIG+	BP transducer signal positive (+), channel 2
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-), channel 1
	9	BP SIG2	BP transducer signal negative (-), channel 2
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

Table 11 Temp connector (T1, T2)

Temp connector (T1, T2)	Pin No	Signal
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Temperature probe presence identification signal
	11	Digital ground

3 Service procedures

3.1 General service information

The field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair, Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Table 12 Recommended tools

Tool	**Order No.**	**For product(s)**
Hemodynamic patient simulator	M1010831	Hemodynamic modules
Adapter cables for simulators		
- Dual temperature adapter cable	402015-004	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Pressure manometer		Hemodynamic modules w/ (P)
Accessories:		
Temperature test set	884515	Hemodynamic modules w/ (T)
Multi-Link ECG accessories, IEC:		
- Multi-link 3-leadwire set	412682-003	Hemodynamic modules w/ (E)

Tool	**Order No.**	**For product(s)**
- Multi-link 5-leadwire set	412681-003	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, C2-C6	416467-004	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-002	Hemodynamic modules w/ (E12)
Multi-Link ECG accessories, AHA:		
- Multi-link 3-leadwire set	412682-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set	4162681-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, V2-V6	416467-003	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-001	Hemodynamic modules w/ (E12)
SpO_2 finger probe	OXY-F-UN	Hemodynamic modules w/ (S)
SpO_2 Interconnect Cable	OXY-ES3	Hemodynamic modules w/ (S)
InvBP transducer	70077-001	Hemodynamic modules w/ (P)
Adult NIBP cuff hose with cuff ID	2021285-001	Hemodynamic modules w/ (NIBP)
Infant cuff hose without cuff ID	414874-001	Hemodynamic modules w/ (NIBP)
Screwdriver		

3.2.2 Recommended parts

Table 13 Recommended parts

Part	**Order No.**	**Notes**
NIBP pump filter	57142	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

Check:

1. Internal parts
   - screws are tightened properly
   - connectors are connected properly
   - NIBP tubing is attached properly
   - there are no loose objects inside the module

2. External parts
   - the front cover and the front panel sticker are intact
   - all connectors are intact and attached properly

– the module box and latch are intact

3.2.4 Functional inspection

3. NIBP pump filter

   Replace the NIBP pump filter, if necessary.

   Reattach the module cover and check that the latch is moving properly.

   Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

   Monitor Setup - ***Waveform Fields - Field 1 - ECG1***
   Field 2 - ECG2
   Field 3 - P1
   Field 4 - P2
   Field 5 - Pleth
   Field 6 - Resp
   Digit Fields - Lower Field 2 - NIBP
   Lower Field 3 - T1+T2

4. Module installation

   Plug in the module. Check that it goes in smoothly and locks up properly

5. Module recognition

   Check that the module is recognized, i.e. all the needed parameter information, except invasive blood pressure, starts to show on the screen.

   Preset ECG, Respiration, InvBP and SpO_2 measurement settings:

   ECG - ***ECG Setup - Hr Source - Auto***
   Pacemaker - Show

   Others - ***Resp Setup - Size - 1.0***
   Resp Rate Source - Auto
   Measurement - On
   Detection Limit - Auto

   Invasive Pressures - ***P1 'Art' Setup - Label - Art***
   P2 'Cvp' Setup - Label - Cvp

   Pulse Oximetry - ***Pleth Scale - Auto***

ECG measurement

6. Module software (serial numbers)

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -
   Service (password 26-23-8)

   Take down the information regarding the module software by selecting ***Scroll Vers*** and turning the ComWheel.

   ✍

7. Communication and memories

   Enter the ***Parameters - ECG*** service menu.

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM state all OK.

   ✍

8. Power frequency

   Check that the power frequency value is set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

   ✍

9. Cable recognition

   Connect a 12-lead ECG trunk cable without a lead set to the module. Check that the message 'Leads off' is displayed on the screen.

   ✍

10. Lead detection

    Connect both 5-leadwire sets to the trunk cable. Connect limb lead electrodes and one electrode from the chest lead set to the same potential. Check that the Cable type shows 10 lead.

    Change the 3-leadwire set to the trunk cable. Check that all the electrodes show OFF in the service menu and the message 'Leads Off' is shown on the screen.

    Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message 'Asystole' appears.

    Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds of the disconnection, and then reconnect the lead. Check the rest of the leads using the same method.

    NOTE: When any of the limb leads is disconnected, the measurement will automatically change to 3 electrode ECG measurement.

    NOTE: The asystole and different leads off messages are shown using certain priority, Even though one of the leads is disconnected, the related leads off message may not appear on the screen.

    NOTE: When RA, LA , LL or RL electrode is disconnected, all six V electrodes show OFF.

NOTE: With PRESTN/RESTN/PRETN modules and 5 lead cable, the state of the V electrode is displayed only for the selected V Lead (***ECG Setup - V Lead: V1 - V6)***.

11. Test with the patient simulator

    Connect the leads to a patient simulator.

    Perform the settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that a normal ECG waveform is shown, the HR value is 160 (±5) and the 'Pacer count' -value is not increasing in the service menu.

    ECG - PACE - WAVE - ASNC

    Check that pacemaker spikes are shown on the ECG waveform, the HR value changes to 75 (±5) and the Pacer count value is increasing according to the shown pacemaker spikes.

    Set the pacemaker option off:

    ECG - PACE - WAVE - NSR

Respiration measurement

12. RESP measurement recognition

    Check that Resp Available and RESP Measurement both show ON in the ESTP: ECG service menu.

13. Test with patient simulator

    Check the respiration measurement with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    BASELINE IMPEDANCE -switch - 500
    LEAD SELECT-switch - II/RL-LL

    RESP - WAVE - NORM
    RATE - 20
    OHMS - 1.0
    RATIO - 1/1
    APNEA - OFF
    SHIFT - OFF

    Check that the RESP waveform is shown and the RR value is 20 (±5). Change the position of the BASELINE IMPEDANCE switch and check that appropriate RESP waveform and RR value are shown again within 30 seconds.

    RESP - APNEA - 32 S

    Check that the monitor activates the APNEA alarm.

NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA alarm may not be activated.

NOTE: When you have the ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

✍

Temperature measurement

14. Communication and memories

    Enter the ESTP: STP service menu:

    Parameters - ESTP : STP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values do not increase faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

    ✍

15. Temperature probe detection

    Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

    Connect the temperature adapter cable to the module temperature connector and a temperature test plug to the adapter cable. Check that the Cable and Probe for T1 show ON and the corresponding temperature value appears on the monitor screen.
    Perform the same check also for the channel T2.

    ✍

16. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more than 0.1°C, calibrate the temperature channels according to the instructions in chapter "Temperature calibration" on page 51."

    ✍

17. Temp test

    Activate the temperature test by selecting ***Temp Test***. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and Temp error shows OFF for both channels in the service menu.

    ✍

18. Module configuration

    Check that the module configuration has been set correctly. The configuration in use is shown beside the text Configuration in the service menu and it can be either STP, ST or TP. Change the configuration in the ***Calibrations - Set Config*** menu, if necessary. To activate the change, reset the module communication by removing and inserting the module.

Invasive blood pressure measurement

19. Membrane keys

    Check the front panel membrane keys that are related to the InvBP measurement.

    Press each of the keys for at least one second. Check that the pressed key is identified, i.e. one of the texts for Buttons changes from OFF to ON in the service menu.

20. Cable and transducer detection

    Check that the Cable and Probe for P1 show OFF. Connect the InvBP adapter cable to the module, connecta cable with an invasive blood pressure transducer to the adapter cable and check that the Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

    Perform the same check also for the InvBP channel P2.

21. Calibration

    Calibrate the InvBP channels P1 and P2 according to the instructions in chapter “Invasive pressure calibration” on page 51.“

22. Test with patient simulator

    Check the InvBP channels with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    SENSITIVITY - switch - 5 µV/V/mmHg

    ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM
    2 - WAVE - ATM

    Restore the normal monitoring screen by pressing the key **Normal Screen**.

    Connect cables from the channels BP1 and BP2 to the module connectors. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

    BP - 1 - WAVE - ART
    2 - WAVE - CVP

    Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

Check that the HR value is calculated from P1, when ECG is not measured (ECG cable disconnected).

✍

Sp0$_2$ measurement

23. Sp0$_2$ probe detection

    Check that the message 'No probe' is shown, when no Sp0$_2$ sensor is connected to the module. Connect an Sp0$_2$ finger probe to the module (with the interconnection cable, if needed). Check that the message 'Probe off' is shown when the probe is not connected to a finger.

    ✍

24. Test measurement

    Connect the Sp0$_2$ probe onto your finger. Check that the reading of 95-99 and Sp0$_2$ waveform appears. Check that the HR value is calculated from Sp0$_2$ when ECG and InvBP (P1) are not measured.

    ✍

Non Invasive Blood Pressure measurement

25. Communication and memories

    Enter the NIBP module service menu:

    Parameters - NIBP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

    ✍

26. Membrane keys

    Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys for at least one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu, when the key is released back up again.

    ✍

27. Pump and valves

    Check the pump and valves.

    Select ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

    Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

Select ***Open Exh2***. Press the ComWheel and check that the pressure inside the tubing system starts to drop, then press the ComWheel again. If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

Select ***Set Valve***. Press the ComWheel and set the value under the text Pulse Valve to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

✍

28. Leak test

    Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.

    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

29. Calibration check

    Recalibrate the NIBP measurement according to the instructions in chapter "NIBP calibrations" on page 49. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** - ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±20 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

    ✍

30. Safety valve functions

    Select ***Safety Valve*** from the NIBP service menu.

    Keep the pressure manometer connected to the cuff connector.

    NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example a calibration gas bottle.

    Select ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 270 - 330 mmHg.

    Select ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***. Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values 'Max press' and '2 s after stop' are all now within 135 to 165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

    ✍

31. Cuff related messages

    Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.

    Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 70 seconds.

    Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 70 seconds.

    ✍

32. Test measurement

    Check that the automatic inflation limits are in use:

    NIBP - ***NIBP Setup - Inflation Limits - Auto - Previous Menu***

    Connect the cuff onto your arm, select ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check that the module identifies the cuff, i.e. the text Adult appears in the NIBP digit field for a short moment.
    Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

    Disconnect the cuff hose.

    ✍

33. NIBP hose detection

    Press the **Start/ Cancel** module or side panel key and check that the 'Cuff loose' message appears in the NIBP digit field.
    Attach a NIBP cuff hose without cuff identification and check that the module identifies the hose:

    - The message 'Select inflation limits' appears in the NIBP digit field.
    - When you try to start the measurement, the monitor automatically opens the selections ***NIBP Setup - Inflation Limits.***

    ✍

All modules

34. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

35. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

    ✍

36. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

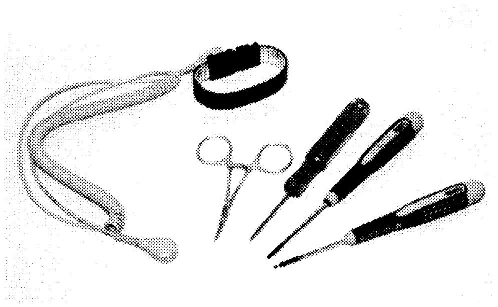
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed

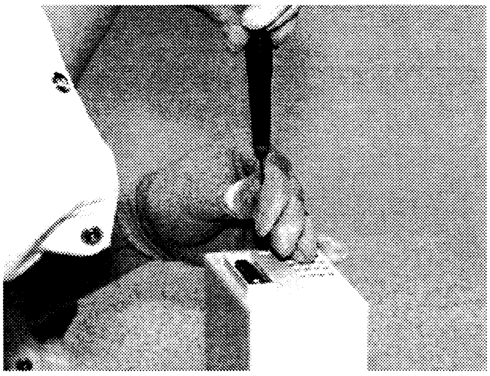


- torx screwdrivers; T6, T8
- flat blade screwdriver
- pincers
- antistatic wristband

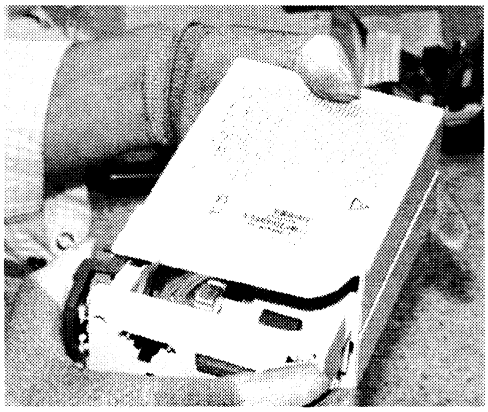
CAUTION When reassembling the module, make sure that all cables are reconnected properly.

3.3.3 To disassemble the module

In case you are replacing either the Front chassis unit or the manifold, start by removing the Module Front Cover from the module by releasing the snaps that hold the front cover to the front chassis. Then follow the disassemle instructions

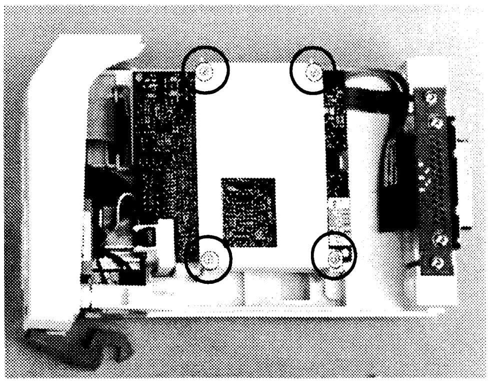


1. Remove the two screws (T8) holding the module cover to the module frame from the back of the module.



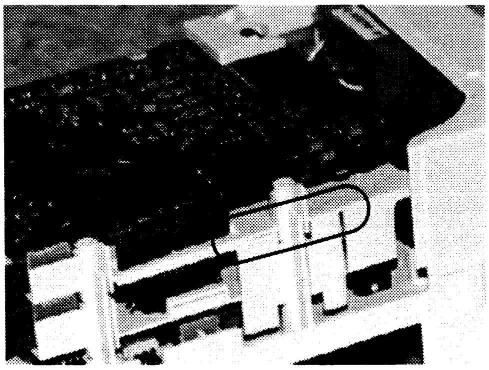
2. While pressing the release latch, pull the module cover slowly backwards and remove it from the main body.

NOTE: When reassembling, be carefull not to damage the membrane keyboard flex. Guide the flex inside the frame and the module casing.

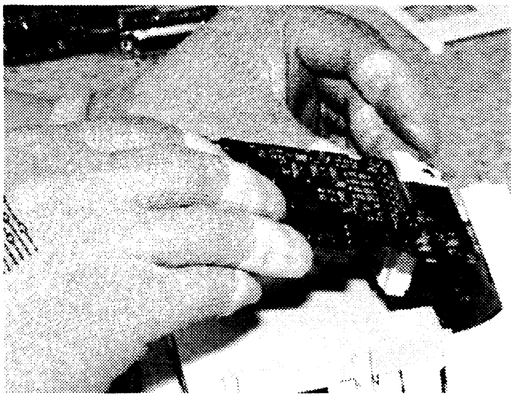


3. To remove the ECG board

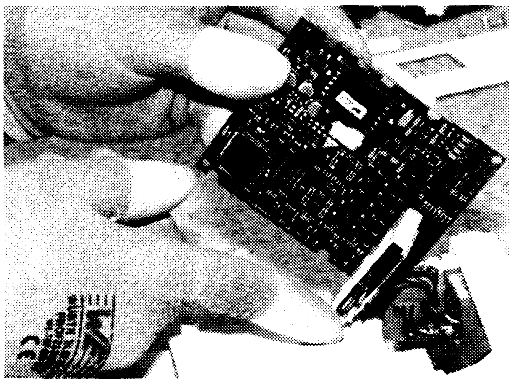
- Remove the four screws (T6) holding the insulator cover and lift the cover up.



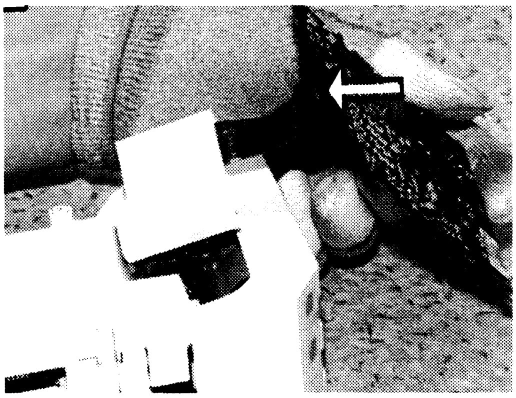
NOTE: When reassembling, push the ECG board a little to ensure that the insulator plates are correctly reassembled. Guide the upper plate inside the lips of the lower plate.



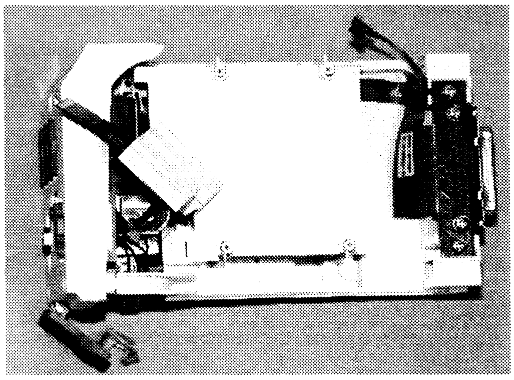
- Lift the ECG board a little and disconnect the module bus connector from the ECG board.
- Carefully lift the board together with the ECG input unit up.



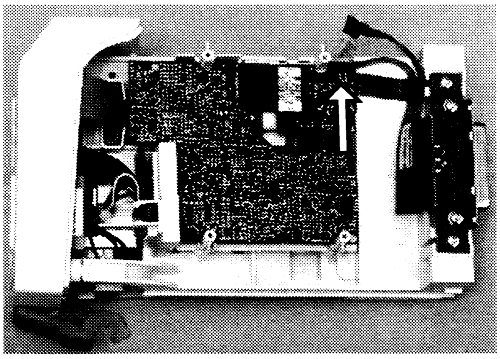
- Turn the ECG board 180 degrees around the input unit.



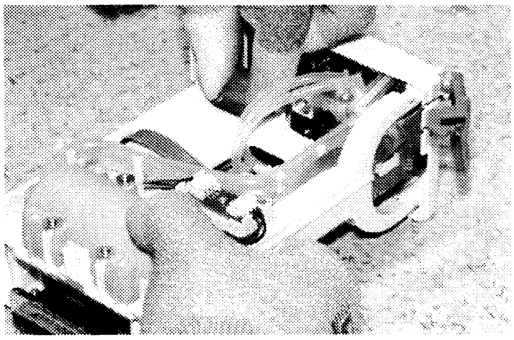
- Disconnect the ECG input flex connector from the ECG board. Be carefull not to damage the flex.



4. To remove the STP board.
- Lift the ECG-STP board insulator plate up.

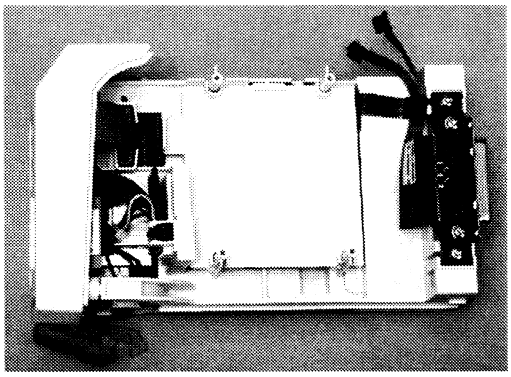


- Disconnect the module bus connector from the STP board.



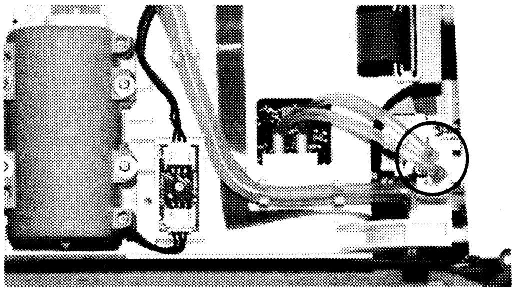
- Flip the module upside down and disconnect the STP input flex connector through the hole in the module frame. Flip the module over again
- Remove the STP board.

NOTE: When reassembling, be carefull not to damage the STP input flex. Make sure the STP input flex connector is properly connected.



5. To remove the NIBP board:

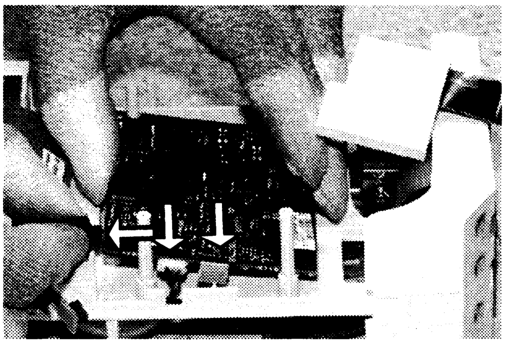
- Lift the STP-NIBP board insulator plate up.



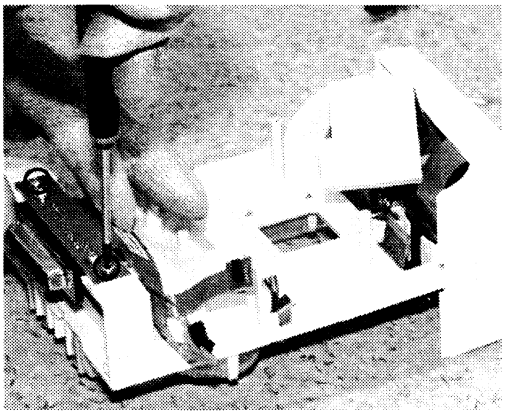
- Flip the module over and disconnect the hoses (2 pcs) coming from the manifold.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

-

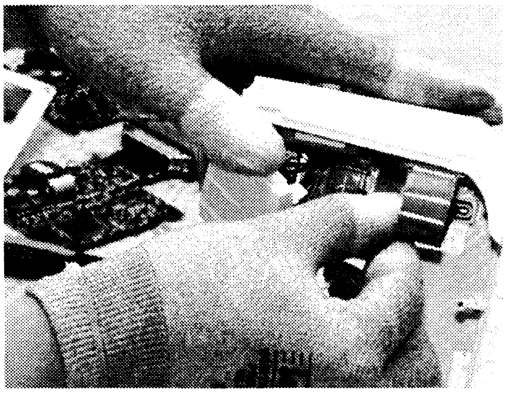


- Flip the module over again. Lift the NIBP board carefully and disconnect the module bus connector, pump connector and NIBP flex connector from the NIBP board.
- Remove the NIBP board.



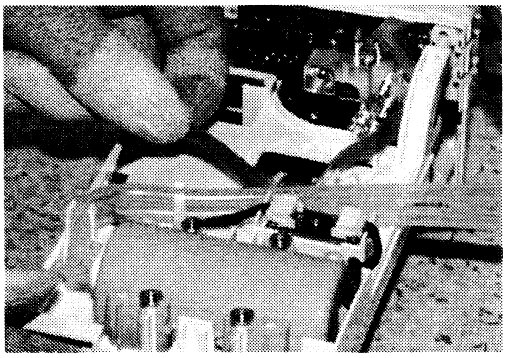
6. To remove the module bus connector:

- Remove the two screws (T8) holding the connector to the frame.



7. To remove the Front Chassis Unit:

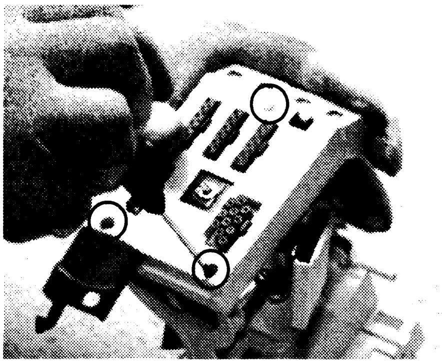
- Carefully push/ pull the STP input flex connector through the ferrites to the other side of the frame. The ferrites should stay in place, if not, remember to reassemble them.



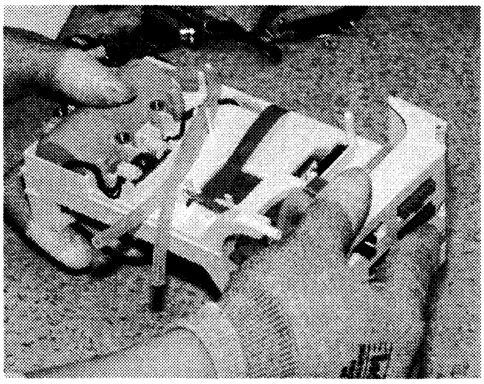
- To release the NIBP flex board:
- Disconnect the hoses (2 pcs) from the manifold and lift them up from the holders to release the NIBP flex board.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

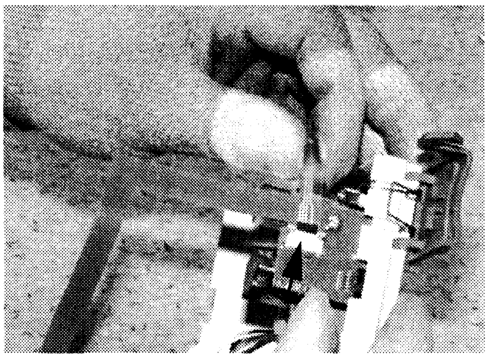
- Pull the NIBP flex board through the frame.



- Remove the three screws (T8) holding the front chassis to the module frame.

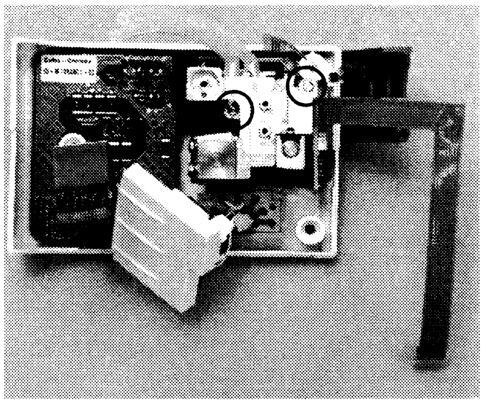


- Detach the front chassis unit from the module frame. Be carefull not to damage the NIBP flex board.

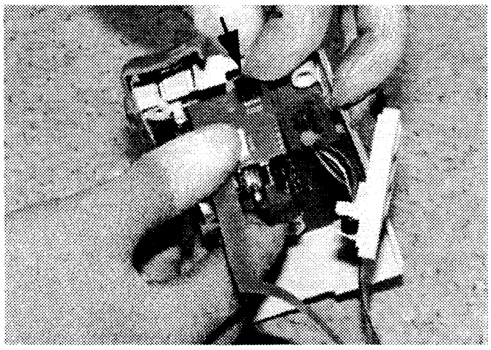


8. To remove the manifold:

- Open the connector lock from the NIBP flex board and disconnect the membrane keyboard flex.

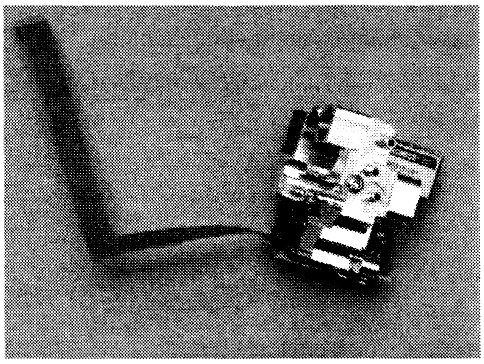


- Remove the two (T6) screws holding the manifold to the Front chassis.



- Disconnect the NIBP flex board connector from the STP input board. Lift the manifold carefully aside. Be careful not to damage the NIBP flex board.

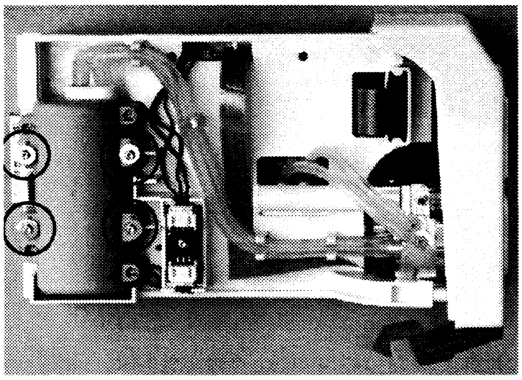
NOTE: When reassembling, make sure that the NIBP flex board is properly connected (all pins connected) to the STP input board.



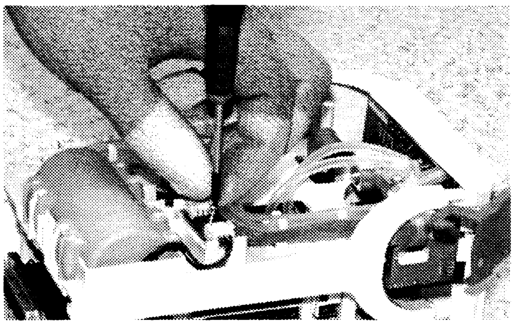
To reassemble the module, reverse the order of the disassembly steps. Pay special attention to the NOTES during the reassembling.

Always perform the "Service check" after reassembling the module.

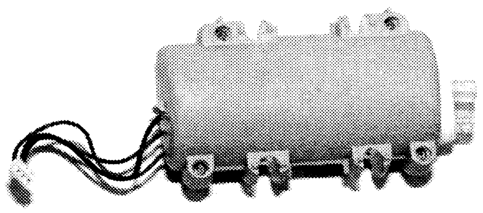
To remove the pump unit



1. Follow the disassemble instruction steps 1 and 2.
2. Remove the four screws (T6) with washers holding the NIBP pump to the frame.



3. Remove the screw (T6) holding the pump connector board to the insulator plate and lift the board up. Disconnect the pump connector.



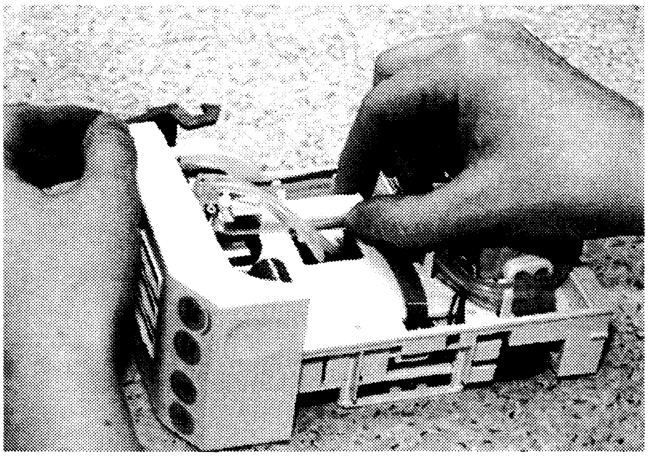
4. Disconnect the hoses and remove the the pump unit.

NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.3.4 To replace the NIBP filter:



1. Follow the disassemble instruction steps 1and 2.
2. Remove the NIBP filter cover and replace the filter.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. The processor automatically maintains the zeroing pressure. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

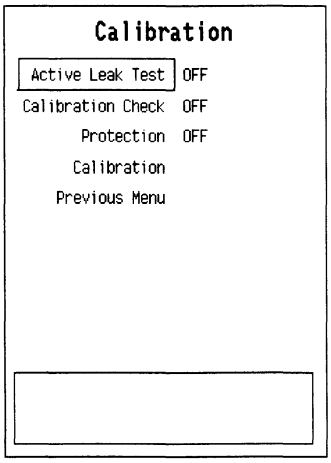
Recalibrate the NIBP measurement once a year. The checking and recalibration can be done in the NIBP service menu.

The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case, the auto zeroing is performed at start - remove the hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.

Calibration check

1. Enter ***Calibration*** menu.



Calibration

Active Leak Test OFF
Calibration Check OFF
Protection OFF
Calibration
Previous Menu

2. Select ***Calibration Check*** and push the ComWheel.
3. Connect an external precision manometer to the module.
4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display (The zeroing offset is automatically subtracted from the pressure readings).

Table 3 NIBP calibration check pressures

Pressure	Max. error	Example
0 mmHg	±5 mmHg (=zero offset)	-1
100 mmHg	100 ±2 mmHg	100 ±2
200 mmHg	200 ±3 mmHg	200 ±3

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

Calibration

1. Enter ***Calibration*** menu.
2. Remove the hoses from the front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps a, b, and c.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the whole procedure.

a. Press the NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds to enable the calibration. This enables menu selection ***Protection***. The message 'Calibration switch ON!' appears.

b. Select ***Protection OFF*** in the Calibration menu and press the ComWheel.

c. Press the buttons again for 3 seconds. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' appears.

- Start Calibration by pressing the ComWheel. Messages 'Zeroing' and 'Zeroed' will appear in the NIBP message field. After this a pressure bar and text 'Calibrating' will appear.
- Connect an external mercury manometer with a pump to the module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure of about 200 mmHg according to the manometer. Calibration is possible in the range of 150 to 250 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message 'Calibrated' will appear on the NIBP digit field after a few seconds, which means that the calibration succeeded, and the new calibration data is saved in EEPROM.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example, change the value one step higher and then back one step lower. 'Calibrated' text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

- To set the protection on:
  Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds. Select ***Protection ON*** and push the ComWheel. Then press the buttons again for three seconds.
- Remove the module from the frame and plug it back again. Then perform Calibration check (see the preceding page) to verify the new calibration.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from GE Healthcare, order code 884515.

Calibrate the temperature, when the measured test values differ for more than ±0.1 °C, and always after STP board replacement.

1. Enter ESTPR: STP service menu.
2. Enter ***Calibrations*** menu.
3. Choose ***Protection OFF*** in protect mode.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Push the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Push the ComWheel.
9. Choose ***Protection ON*** in protect mode.

3.4.3 Invasive pressure calibration

Calibrate the invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when the STP board is replaced.

1. Enter ESTPR: the STP service menu.
   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message 'Calibrated' will appear on the display.

4 Troubleshooting

4.1 Troubleshooting charts

See also the “User’s Reference Manual” for more troubleshooting procedures.

4.1.1 NIBP

Problem	**Cause**	**What to do**
No NIBP value displayed	NIBP not selected on screen.	Check monitor setup.
NIBP menu fading	No PRESTN module, module not properly connected or NIBP and PRESTN module connected at the same time.	Plug in the module.
‘Artifacts’ message	Unsuccessful measurement due to patient movement, shivering, external artifact or weak signal.	
‘Weak pulsation’ message	Weak or unstable oscillation pulses due to: • artifacts • weak pulse pressure due to arrhythmias • improper cuff position or attachment • too few pulses detected • weak or unusual blood circulation • obese subject	Check patient condition and retry. Check any leaks and retry. Use proper size of cuff. Check attachment.
Call service ‘Error X’ message	NIBP hardware error. X = error number.	See the description of the error message code in NIBP error code explanation, the causes and the solutions listed in the next chapter.
Cuff loose-message	1. Hose and/or cuff not connected.	1. Connect the hose and the cuff.
	2. Hose and cuff connected. Reasons:	
	- cuff loosely wrapped	- tighten the cuff
	- leakage in cuff or hose	- replace cuff/hose
	- leakage inside module	- check internal tubing and fix if necessary
	- pump does not work	- Check pump connector; if OK, replace the NIBP Pump Unit.

Problem	**Cause**	**What to do**
Cuff ID not working	1. Defective cuff ID holes in the NIBP cuff hose	- Replace NIBP cuff hose.
	2. NIBP flex board connector wrongly connected	- Check that the NIBP flex board connector is properly connected to the STP input board: all pins have to be connected.
	3. Cuff ID switches defective	- To check the switches, attach a NIBP cuff hose without the cuff ID and check that the message 'Select inflation limit' appears. If not, replace the Front Panel Unit.
'Air leakage' message	1. Hose or cuff leaking. Reasons:	1. Replace cuff
	- cuff damaged	- replace cuff
	- cuff connector damaged	- replace cuff connector (if the fault is in hose connector)
	- O-ring damaged or missing	- replace O-ring
	- hose double connector damaged	- replace NIBP cuff hose
	2. Hose and cuff OK. Reasons:	2. Connect or replace tube
	- leakage inside the module	- replace the whole tubing
	- tube disconnected or damaged	- fix connections
	- air chamber leaking	-
	- tubes or valve(s) damaged	- replace tubes/valve(s)
'Unable to measure Sys' message	Systolic blood pressure probably higher than the inflation pressure or artifacts.	Automatic retrial with increased pressure.

Problem	**Cause**	**What to do**
'Cuff occlusion' message	1. Cuff and/or hose occluded. Reason:	
	- cuff tube kinked	- straighten tube
	- tube inside module kinked	- straighten tube
	- occlusion inside/outside module	- remove occlusion
	2. Cuff, hose, and tubes OK. Reason:	
	- fault in pressure transducer	- replace the NIBP board
	- fault in A/D converter	- replace the NIBP board
	- faulty calibration	- check calibration
'Calibration switch on' message	EEPROM protection has been handled by pressing module buttons **Auto ON/OFF** and **Start/Cancel** simultaneously for 3 seconds.	Enables setting the protection OFF in the Calibration menu. Press the buttons again if you are not going to calibrate.
Calibration not protected - message.	Calibration protection is set to OFF.	Set the protection ON in the NIBP Calibration menu.

4.1.2 NIBP error code explanation

Code	Problem	What to do
0	RAM failure; memory failure	Change the NIBP board.
1	ROM checksum error; memory failure	Change the NIBP board.
2	Pump current failure	Check short circuits. Change the NIBP board.
3	Safety CPU internal test failure or pressure sensor reference voltage failure	Change the NIBP board.
4	EEPROM protection error	Press module buttons **Auto ON/OFF** and **Start/ Cancel** simultaneously for 3 seconds.
5	Calibration not protected	Protect calibration by selecting Protection ON in the NIBP calibration menu.
6	Pressure sensors give different readings	Try to remeasure. If the problem persists, recalibrate. If the problem still persists, change the NIPB board.
7	Calibration failure	Reset the module and recalibrate. If this does not help, change the NIBP board.
8	Exhaust Valve occlusion	Check and clean the tubing and air chamber. If this does not help, change the NIBP board.
9	Measurement related error	Automatic recovery.
10	EEPROM checksum error; memory failure	Change the NIBP board.
11	Auto zero range exceeded	Calibrate the NIBP.
12	Communication break; temporal break down of communication from monitor detected	Automatic recovery.
13	Illegal neonate cuff with identifying magnet connected	Remove the cuff.
14	-	
15	Safety CPU pressure calibration error	Recalibrate. If this does not help, change the NIBP board.
16	Communication error between CPUs	Change the NIBP board.
17	Safety CPU has cut down power from pneumatics due to repeating safety limit violations	Reset the module. If the problem persists, change the NIBP board.

4.1.3 ECG

Problem	**Cause**	**What to do**
HR numerical display shows '---'	No heart rate available.	If no ECG waveform, check 'LEADS OFF' message and connect the leads.
		If ECG waveform exists, check the heart rate source e.g. in the ECG Setup menu behind ECG key.
Unacceptable ECG waveform	Poor electrode or poor electrode skin contact.	Electrodes from different manufacturers are used. /Too much/little gel is used.
	Poor electrode condition.	Electrodes are dried out.
	Improper site of electrodes.	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation.	Remove body hair. Clean the attachment site carefully with alcohol.
	Improper bandwidth filter.	Check the filter.
	Faulty/ dirty ECG cable.	Change a new cable.
No ECG trace	Waveform not selected on screen.	Press the **Monitor Setup** key and make adjustments.
	Module not plugged in correctly.	Plug in.
Noise-message	High frequency or 50/60 Hz noise.	Isolate noise source.

4.1.4 Impedance respiration

Problem	**Cause**	**What to do**
No resp trace	Waveform not selected on the screen	Press the **Monitor Setup** key and make adjustments.
	Module not plugged in correctly	Re-plug the module.

Problem	**Cause**	**What to do**
Unacceptable resp waveform	Poor electrode or poor electrode skin contact	Electrodes from different manufacturers are used. Too much/little gel is used.
	Poor electrode condition	Electrodes are dried out.
	Improper site of electrodes	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation	Remove body hair. Clean the attachment site carefully with alcohol.
	Faulty/ dirty ECG cable.	Change a new cable.
Message: 'SMALL RESP CURVE'	Respiration signal is very small	With 3-lead cable, try another lead connection I, II, III or try 5-lead cable.
Message: 'APNEA ALARM', and respiration waveform normal	Respiration source is CO_2	Check the respiration source and change it to the correct one.

4.1.5 Pulse oximetry (SpO_2)

Problem	Cause	What to do
Message 'NO PROBE'	No probe connected to the monitor.	Check probe connections.
	Probe faulty.	Change the probe.
Message 'PROBE OFF' though probe properly attached to the patient	Unsuitable site.	Try another site.
	Probe faulty.	Try another probe.
	Probe connection cable not connected to probe.	Connect the cable to probe.
Finger probe falls off	1. Probe is slippery.	1. Wipe with 70% isopropyl alcohol and allow drying.
	2. Finger is too thin or thick.	2. Try other fingers, or other probe types.
Weak signal artifacts	Poor perfusion.	Try another place.
	Movement artifacts.	
	Shivering.	
Message 'NO PULSE'	Pulse search > 20 sec. and low SpO_2 or low pulse rate.	Try other fingers.
Message 'ARTIFACT'	Pulse modulation exceeds the present scale.	Try another place or another probe.
Message 'CHECK PROBE'	DC value not in balance.	Try another probe.
Message 'POOR SIGNAL'	Poor perfusion. Modulation (Red or Ired) < 0.25%	Check that the sensor is positioned correctly to the patient.
Message 'FAULTY PROBE'	Probe is faulty.	Change the probe.
No SpO_2	No waveform selected on screen.	Check the selected SpO_2 waveforms by pressing **Monitor Setup** key and selecting ***Modify waveforms***.
	Wrong configuration setting.	Check the configuration settings from the ESTPR:STP/Calibrations menu (**Monitor Setup** - ***Install/Service - Service - Parameters***)

4.1.6 Temperature

Problem	Cause	What to do
Message 'TEMPERATURE ERROR'	Faulty calibration.	Perform calibration. If it does not help, check that the front panel connector is properly connected to the STP board.

Problem	**Cause**	**What to do**
No temperature displayed	Wrong type of probe.	Use correct probe.
	Temperature out of measurable range.	The range is between 10 and 45 °C.
	Temperature calibration not protected.	Set the protection ON in the Service Menu.

4.1.7 Invasive blood pressure

Problem	**Cause**	**What to do**
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check the selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms.
		Check that the pressure transducer is open to the patient.
	Wrong configuration setting	Check the configuration setting from the ESTP:STP/Calibrations menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***)
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P1 /P2 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel.
		Offset is > 150 mmHg. Open the transducer to air and zero the channel.
		Defective transducer. Replace it and zero the channel.
'Calibration failed' message	Unsuccessful calibration of P1/P2 (number field), possibly due to a pulsating waveform	Turn the transducer to sphygmomanometer and try again (zeroing takes place first).
		Gain is beyond the limits (± 20% of the default gain). Replace the transducer.
Out of range < 40 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel.

Problem	**Cause**	**What to do**
Out of range > 320 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check the transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowcharts

4.2.1 Module troubleshooting for NIBP parameter

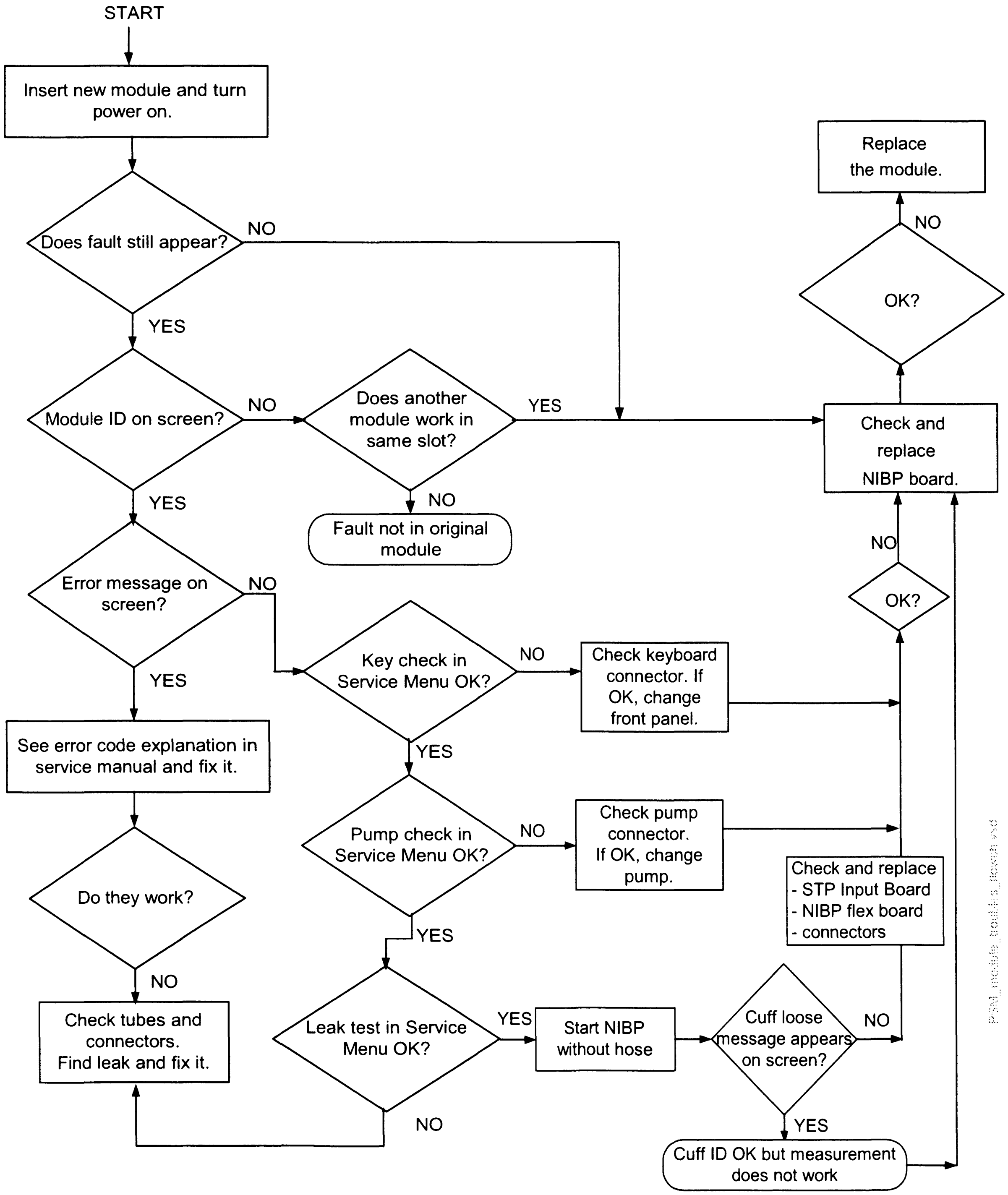

START
Insert new module and turn power on.
Does fault still appear?
NO
YES
Module ID on screen?
NO
Does another module work in same slot?
YES
NO
Fault not in original module
YES
Error message on screen?
NO
YES
See error code explanation in service manual and fix it.
Do they work?
NO
Check tubes and connectors. Find leak and fix it.
Key check in Service Menu OK?
NO
Check keyboard connector. If OK, change front panel.
YES
Pump check in Service Menu OK?
NO
Check pump connector. If OK, change pump.
YES
Leak test in Service Menu OK?
YES
NO
Start NIBP without hose
Cuff loose message appears on screen?
NO
YES
Cuff ID OK but measurement does not work
Check and replace
- STP Input Board
- NIBP flex board
- connectors
OK?
NO
Check and replace NIBP board.
OK?
NO
Replace the module.

Figure 13 Troubleshooting flowchart for NIBP Parameter

4.2.2 Module troubleshooting for parameters ESTPR

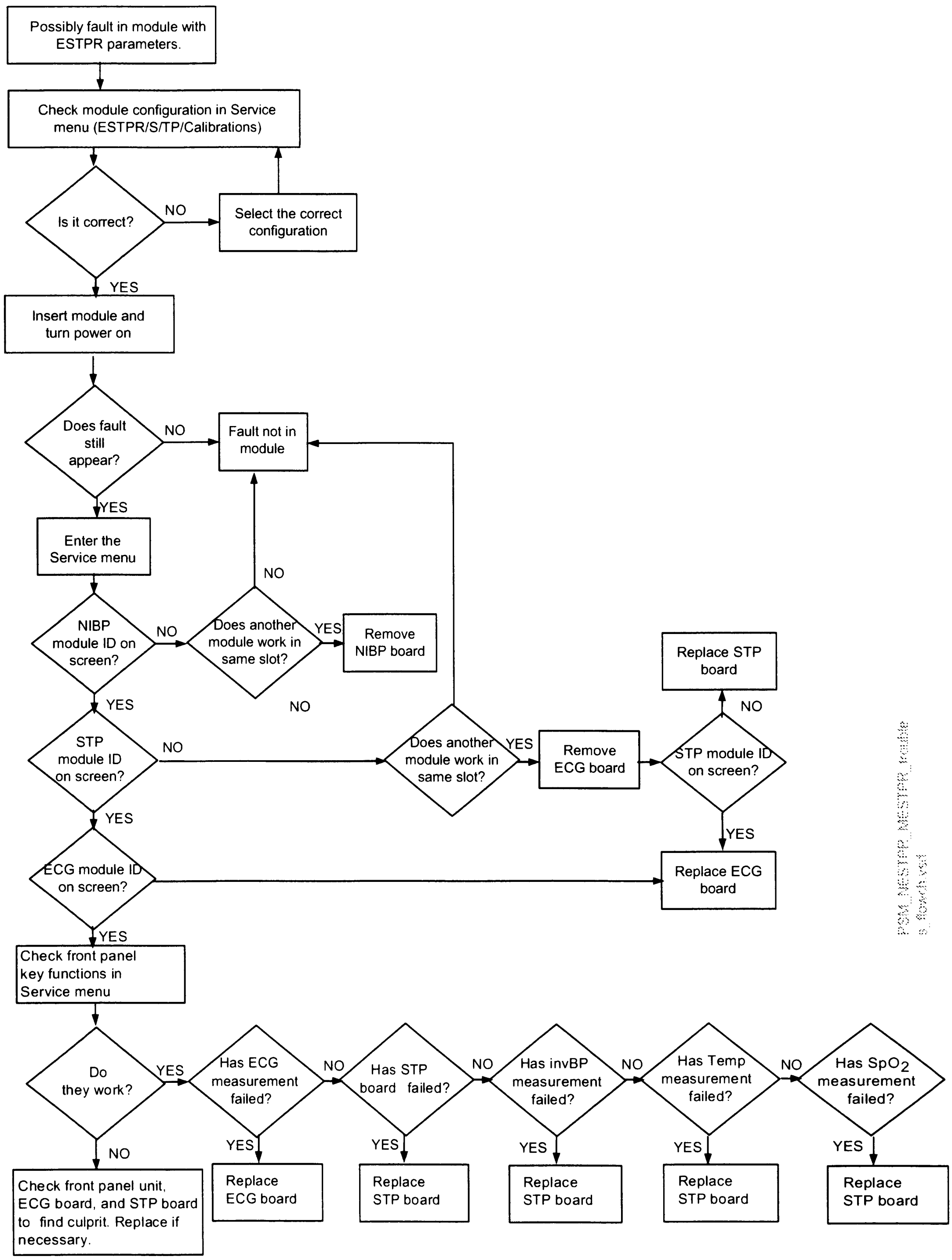

Possibly fault in module with ESTPR parameters.
Check module configuration in Service menu (ESTPR/S/TP/Calibrations)
Is it correct?
NO
Select the correct configuration
YES
Insert module and turn power on
Does fault still appear?
NO
Fault not in module
YES
Enter the Service menu
NO
NIBP module ID on screen?
NO
Does another module work in same slot?
YES
Remove NIBP board
NO
YES
STP module ID on screen?
NO
Does another module work in same slot?
YES
Remove ECG board
STP module ID on screen?
NO
Replace STP board
YES
Replace ECG board
YES
ECG module ID on screen?
YES
Check front panel key functions in Service menu
Do they work?
YES
NO
Check front panel unit, ECG board, and STP board to find culprit. Replace if necessary.
Has ECG measurement failed?
NO
YES
Replace ECG board
Has STP board failed?
NO
YES
Replace STP board
Has invBP measurement failed?
NO
YES
Replace STP board
Has Temp measurement failed?
NO
YES
Replace STP board
Has SpO2 measurement failed?
YES
Replace STP board

Figure 14 **Troubleshooting flowchart for ESTPR Parameters**

APPENDIX A Service check form, Hemodynamic Module, E-PRESTN, E-RESTN, E-PRETN (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

All modules	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. NIBP pump filter	☐	☐	☐	4. Module installation	☐	☐	☐
5. Module recognition	☐	☐	☐				
Notes							

ECG measurement					S/N		
6. Module software (serial numbers)							
ECG/RESP							
STP							
NIBP							
	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
7. Communication and memories	☐	☐	☐	8. Power frequency	☐	☐	☐
9. Cable recognition	☐	☐	☐	10. Lead detection	☐	☐	☐
11. Test with the patient simulator	☐	☐	☐				
Notes							

RESP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
12. RESP measurement recognition	☐	☐	☐	13. Test with patient simulator	☐	☐	☐
Notes							
TEMP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
14. Communication and memories	☐	☐	☐	15. Temperature probe detection	☐	☐	☐
16. Calibration check	☐	☐	☐	17. Temp test	☐	☐	☐
18. Module configuration	☐	☐	☐				
Notes							
InvBP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
19. Membrane keys	☐	☐	☐	20. Cable and transducer detection	☐	☐	☐
21. Calibration	☐	☐	☐	22. Test with patient simulator	☐	☐	☐
Notes							
Sp02 measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
23. Sp02 probe detection	☐	☐	☐	24. Test measurement	☐	☐	☐
Notes							

NIBP measurement				S/N			
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
25. Communication and memories	☐	☐	☐	26. Membrane keys	☐	☐	☐
27. Pump and valves	☐	☐	☐				
28. Leak test							

29. Calibration check	Measured B1	Measured B2	Allowed range
0 mmHg			±9 mmHg
100 mmHg			100 ±2 mmHg
200 mmHg			200 ±3 mmHg
260 mmHg			260 ±4 mmHg
30. Safety valve functions	Measured B1	Measured B2	Allowed range
			270...330 mmHg
			270...330 mmHg
			130...165 mmHg
			130...165 mmHg

	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
31. Cuff related messages	☐	☐	☐	32. Test measurement	☐	☐	☐
Notes							

All modules							
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
34. Electrical safety check	☐	☐	☐	35. Functioning after electrical safety check	☐	☐	☐

All modules	
36. Final cleaning	☐
Notes	

Notes

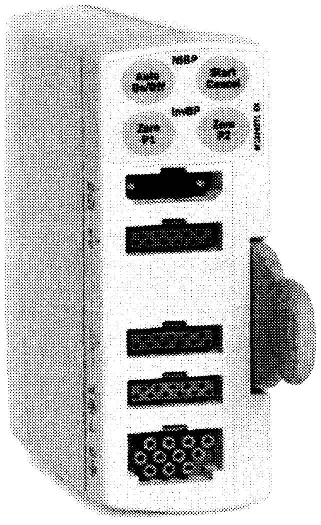
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Patient Side Module, E-PSM, E-PSMP (Rev. 00)

Technical Reference Manual



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1024662-4
June, 2005

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Introduction

This Technical Reference Manual Slot provides information for the maintenance and service of the S/5 Patient Side Modules E-PSMP and E-PSM. Later in this manual modules may be referred to without S/5 for simplicity.

Please also refer to "Technical Reference Manual" of the monitor for system specific information e.g. related documentation, conventions used, symbols on equipment, safety precautions, system description, system installation, interfacing, functional check and planned maintenance.

The E-PSMP and E-PSM modules provide general hemodynamic parameters.

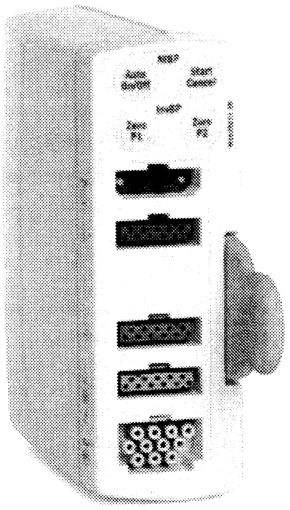


Figure 1 Patient Side Module, E-PSMP

Table 1 Patient Side Module options

Parameter	E-PSMP	E-PSM
Two invasive blood pressures	x	
Impedance respiration	x	x
ECG	x	x
Pulse oximetry	x	x
Two temperatures	x	x
NIBP	x	x

Intended purpose (Indications for use)

The Datex-Ohmeda Patient Side Module (model family E-PSM(P)) and accessories are indicated for the monitoring of hemodynamic parameters of all hospital patients. The hemodynamic parameters of the module comprise ECG including ST-segment and arrhythmia, Impedance respiration, NIBP, Temperature, SpO_2 (including monitoring during conditions of clinical patient motion), and invasive blood pressure.

Impedance respiration measurement is indicated for patients aged 3 and up. The NIBP measurement is indicated for patients who weigh 5kg (11 lb.) and up. This device is indicated for use by qualified medical personnel only.

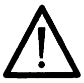
Monitor software compatibility

Datex-Ohmeda Patient Side Module, E-PSM(P) Rev.00 is designed for use with Datex-Ohmeda monitors as follows:

- S/5 FM monitors using software L-FICU03(A) or later.
- S/5 Anesthesia Monitors using software L-ANE04(A) equipped with 5-Module Frame, F-CU5(P) or with S/5 8-Module Frame, F-CU8. With the F-CU8, the E-INTPSM interface module is needed.

S/5 Critical Care Monitors using software L-ICU04(A) equipped with 5-Module Frame, F-CU5(P) or with S/5 8-Module Frame, F-CU8. With the F-CU8, the E-INTPSM interface module is needed.

Equipment safety symbols



When displayed on the E-PSM, E-PSMP module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO$_2$), temperature (T) and invasive pressure (P) measurement

1 Specifications

1.1 General specifications

Module size	51 x 132 (171 w/ tab) x 140 mm
W x D x H	2 x 5.2 (67 w/ tab) x 5.5 in
Module weight	0.6 kg / 1.4 lb.
Power consumption	2.3 W typical (NIBP pump off)
	7.5 W typical (NIBP pump on)
Operation temperature	10 to 40°C / 50 to 104°F

1.2 Typical performance

1.2.1 NIBP

NOTE: Non-invasive blood pressure measurement is intended for patients weighing over 5 kg (11 lb.)

Oscillometric measurement principle.

Measurement range	adult	25 to 260 mmHg
	child	25 to 195 mmHg
	infant	15 to 145 mmHg
Pulse rate range accepted	30 to 250 bpm	
Measurement interval	from 1 min. to 4h	
Typical measuring time	adult	23 s
	infant	20 s
Initial inflation pressure	adult	170 ±10 mmHg
	child	150 ±10 mmHg
	infant	120 ±10 mmHg
Venous stasis	adult	40 ±5 mmHg / 2 min.
	child	40 ±5 mmHg / 2 min.
	infant	30 ±5 mmHg / 1 min.
Cuff widths	see User's Guide	

1.2.2 ECG

Lead selection	I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6
Sweep speeds	12.5, 25, 50 mm/sec.

Display filter

Diagnostic	0.05 to 150 Hz
Monitoring	0.5 to 30 Hz (-3 dB, with 50 Hz reject filter)
	0.5 to 40 Hz (-3 dB, with 60 Hz reject filter)
ST filter	0.05 to 30 Hz (-3 dB, with 50 Hz reject filter)
	0.05 to 40 Hz (-3 dB, with 60 Hz reject filter)

Heart rate from ECG

Range	30 to 250 bpm
Accuracy	±5 bpm or ±5%, whichever is greater
Resolution	1 bpm
Update interval	5 s
Averaging time	5 s

ST levels (in main software)

ST level range	-9 to +9 mm (-0.9 to +0.9 mV)
Resolution	0.1 mm (0.01 mV)
Averaging	calculated from 8 QRS

Pacemaker pulse detection

Detection level	2 to 700 mV
Pulse duration	0.5 to 2 ms

The monitor is specified for both of the methods A and B in ANSI/AAMI EC13 4.1.4.2.

Direct ECG and Synchronization

for specifications see section “Specifications” in the “Frame Unit Technical Reference Slot”

1.2.3 Pulse oximetry

Measurement range	0 to 100%
Calibration range	70 to 100 %
Accuracy[1]	100 to 70%, ±2 digits ±3 digits during clinical patient motion 69 to 0%, unspecified
Display resolution	1 digit = 1% of SpO_2
Display averaging time	Slow, Normal, beat-to-beat
Pulse beep pitch	varies with SpO_2 level

The monitor is calibrated against functional oxygen saturation SpO_2 func.

Pulse rate from Pleth

Measurement range	30 to 250 bpm
Accuracy	30 to 100, ±5 bpm, 100 to 250, ±5%
Resolution	1 bpm
Display averaging	10 s

Adjustable pulse beep volume.

Pleth waveform

Scales	2, 5, 10, 20, 50 mod%, Auto

Start up scale is 20 mod% if AUTO is not selected to be the default setting.

1.2.4 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C) ±0.2 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.1 °F)
Temperature test	automatic (every 10 min.)
Probe type	compatible with YSI 400 and 700 series
Single use sensors	±0.2 °C (25 to 45.0 °C) ±0.3 °C (10 to 24.9 °C)

---

[1] Accuracy is based on deep hypoxia studies with volunteered subjects during motion and non-motion conditions over a wide range of arterial blood oxygen saturation as compared to arterial blood CO-Oximetry. Accuracy may depend on the sensor used, please refer to the instructions for use in the accessory package.

1.2.5 Invasive blood pressure

Measurement range	-40 to 320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Scales	upper limit is adjustable between 10 and 300 mmHg in steps or 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

Digital display

Range	-40 to 320 mmHg
Resolution	±1 mmHg

Waveform display

Range	-30 to 300 mmHg

Pulse rate from arterial pressure

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5 bpm or ±5% whichever is greater

1.2.6 Respiration

NOTE: The respiration measurement is intended for patients over three years old

Measurement range	4 to 120 breath/min
Accuracy	±5 breath/min or ±5%
Resolution	1 breath/min
Averaging time	30 s
Update interval	10 s

Respiration waveform

Sweep Speeds	6.25 mm/s and 0.625 mm/s

1.3 Technical specifications

1.3.1 NIBP

Deflation rate, PR dep.	3 to 8 mmHg/s
Inflation time	20 to 185 mmHg, 1 to 5 s

Automatic software control, max. inflation pressure

adult	280 ±10 mmHg
child	200 ±10 mmHg
infant	145 ±5 mmHg

Over pressure limit, stops measurement after 2 seconds

adult	320 mmHg
child	220 mmHg
infant	160 mmHg

The safety circuit limits the maximum cuff pressure to 320 mmHg in adult/child mode or to 160 mmHg in infant mode. Independent timing circuit limits the pressurizing (>15 mmHg) time to 3 minutes maximum in adult/child mode, and to 90 seconds at (>5mmHg) in infant mode.

Zeroing to ambient pressure is done automatically.

Inflation pressure is adjusted according to the previous systolic pressure, typically 40 mmHg above. If the systolic pressure is not found, the inflation pressure is increased typically 50 mmHg.

Max. measurement time	adult	120 s
	child	120 s
	infant	75 s

Pressure transducer accuracy is better than ±3 mmHg or ±2% whichever is greater.
Max. error ±4 mmHg.

Protection against electrical shock	Type BF defibrillation proof

1.3.2 ECG

Defibrillation protection	5000 V, 360 J
Recovery time	5 s
Input impedance	>2.5 MΩ (10 Hz)
CMRR	>100 dB (ST)
System noise	<30 mV (p-p, RTI)
Allowable offset	±1VDC
Gain range	0.2 to 5.0 cm/mV
Pacemaker pulse detection	2 to 700 mV, 0.5 to 2 ms pulses
Protection against electrical shock	Type CF defibrillator proof

1.3.3 Pulse oximetry

Protection against electrical shock	Type CF defibrillation proof

1.3.4 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.5 Invasive blood pressure

Digital display averaging

Digital displays Art and P1 are averaged over 5 seconds and updated at 5 seconds intervals. All other pressures have respiration artifact rejection.

Accuracy	±5% or ±2 mmHg, whichever is greater
Transducer and input sensitivity	5 µV/V/mmHg
Filter	0 to 4 - 22 Hz adjustable
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	less than 15 s
Protection against electrical shock	Type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified, depending on the transducer/probe used. Please refer to the transducer/probe specification.

1.3.6 Respiration

Excitation frequency, 12-lead ECG	31.25 kHz
Breath detection	automatic, manually adjustable minimum detection: 0.2, 0.4, 0.6, 0.8, 1.0
Input dynamic range	0.2 to 20 Ω
Input impedance range	100 to 5000 Ω
Respiration Rate	min. 4 breath/min max. 120 breath/min
Lead off detection	>3 MΩ

2 Functional description

2.1 Measurement principle

2.1.1 NIBP

NIBP (Non-Invasive Blood Pressure) is an indirect method for measuring blood pressure.

The NIBP measurement is performed according to the oscillometric measuring principle. The cuff is inflated with a pressure slightly higher than the presumed systolic pressure, and deflated at a speed based on the patient's pulse, collecting data from the oscillations caused by the pulsating artery. Based on these oscillations, values for systolic, mean, and diastolic pressures are calculated.

The following parts are necessary for the NIBP measurement:

- E-PSMP/E-PSM module
- twin hose (adult or infant model)
- blood pressure cuffs (various sizes)

2.1.2 ECG

Electrocardiography analyzes the electrical activity of the heart by measuring the electrical potential produced with electrodes placed on the surface of the body.

ECG reflects:

- electrical activity of the heart
- normal/abnormal function of the heart
- effects of anesthesia on heart function
- effects of surgery on heart function

See the “User's Guide” or the “User’s Reference Manual” for electrodes’ positions and other information.

2.1.3 Pulse oximetry

A pulse oximeter measures the light absorption of blood at two wavelengths, one in the near infrared (about 940 nm) and the other in the red region (about 660 nm) of the light spectrum. These wavelengths are emitted by LEDs in the SpO_2 probe, the light is transmitted through peripheral tissue and is finally detected by a PIN-diode opposite the LEDs in the probe. The pulse oximeter derives the oxygen saturation (SpO_2) using an empirically determined relationship between the relative absorption at the two wavelengths and the arterial oxygen saturation SaO_2.

In order to measure the arterial saturation accurately, pulse oximeters use the component of light absorption giving variations synchronous with heart beat as primary information on the arterial saturation.

A general limitation of pulse oximetry is that due to the use of only two wavelengths, only two hemoglobin species can be discriminated by the measurement.

The modern pulse oximeters are empirically calibrated either against fractional saturation SaO_2frac;

$$SaO_2frac = \frac{HbO_2}{HbO_2 + Hb + Dyshemoglobin}$$

Formula 1

or against functional saturation SaO_2func;

$$SaO_2func = \frac{HbO_2}{HbO_2 + Hb}$$

Formula 2

Functional saturation is more insensitive to changes of carboxyhemoglobin and methemoglobin concentrations in blood.

The oxygen saturation percentage SpO_2 measured by the Datex-Ohmeda module is calibrated against functional saturation SaO_2func. The advantage of this method is that the accuracy of SpO_2 measurement relative to SaO_2func can be maintained even at rather high concentrations of carboxyhemoglobin in blood. Independent of the calibration method, pulse oximeters are not able to correctly measure oxygen content of the arterial blood at elevated carboxyhemoglobin or methemoglobin levels.

Plethysmographic pulse wave

The plethysmographic waveform is derived from the IR signal and reflects the blood pulsation at the measuring site. Thus the amplitude of the waveform represents the perfusion.

Pulse rate

The pulse rate calculation is done by peak detection of the plethysmographic pulse wave. The signals are filtered to reduce noise and checked to separate artifacts.

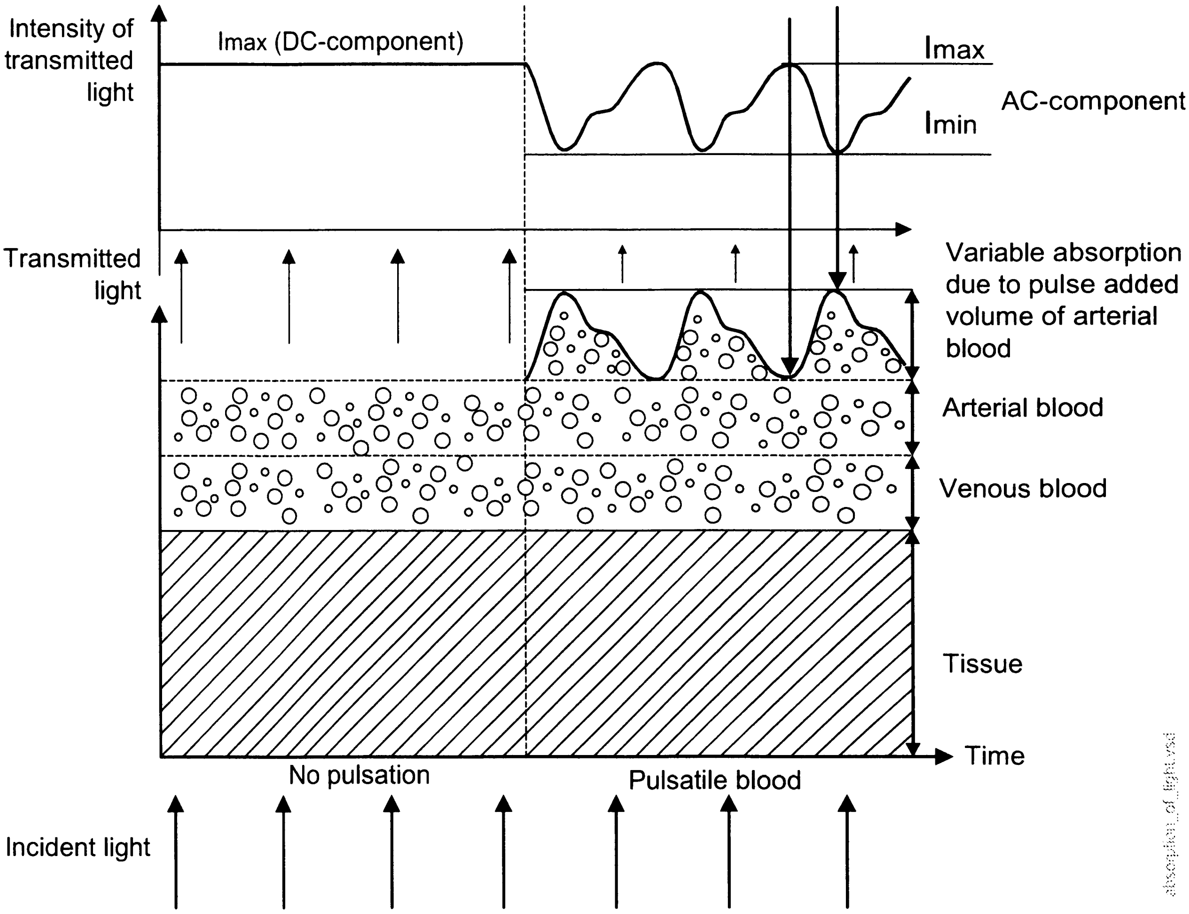

Intensity of transmitted light
Imax (DC-component)
Imax
Imin
AC-component
Transmitted light
Variable absorption due to pulse added volume of arterial blood
Arterial blood
Venous blood
Tissue
Time
No pulsation
Pulsatile blood
Incident light
absorption_of_light.vsd

Figure 2 Absorption of infrared light in the finger

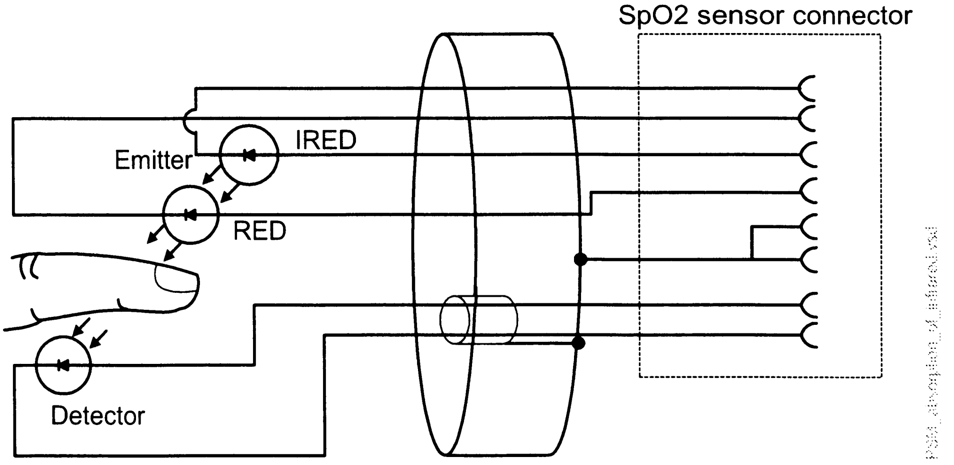

SpO2 sensor connector
Emitter
IRED
RED
Detector
SpO2_absorption_of_infrared.vsd

Figure 3 Pulse oximetry probe parts layout and schematic diagram

The standard probe is a finger clamp probe which contains the light source LEDs in one half and the photodiode detector in the other half. Different kinds of probes are available from Datex-Ohmeda.

2.1.4 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called NTC (Negative Temperature Coefficient) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current through the resistor and measuring the voltage that is generated across it.

Datex-Ohmeda E-PSM(P) module uses the constant current method. The NTC-resistor is connected in series with a normal resistor and a constant current is applied through them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.1.5 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of a connecting tubing, a pressure transducer, an intravenous bag of normal saline, all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

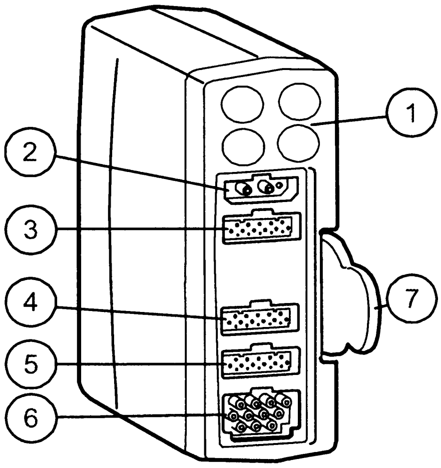
The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.6 Respiration

Impedance respiration is measured across the thorax between ECG electrodes. The respiration signal is made by supplying current between the electrodes and by measuring the differential current from the electrodes. The signal measured is the impedance change caused by breathing. The respiration rate is calculated from these impedance changes, and the respiration waveform is displayed on the screen.

2.2 Main components

2.2.1 E-PSMP/E-PSM



1. Module keys
2. NIBP connector
3. InvBP connector in E-PSMP only
4. Temperature connector
5. SpO_2 connector
6. ECG and impedance respiration connector
7. Tab for removing the module

Figure 4 Front panel of E-PSMP

The E-PSMP and E-PSM modules contain three main PC boards, the STP board, the ECG board, and the NIBP board. Each of these boards contain a processor and software in the processor flash memory. The boards produce their own supply voltages from the Vmod 13.8-16 V line that is available via the module bus connector. One exception, the NIBP board provides +5V for the ECG and STP board non-isolated side components. The NIBP board provides also the synchronization signal for the ECG and STP board power supplies.

There are two input boards; the STP input board and the ECG input board attached to the front panel of the module. The front panel has five connectors and four keys. There is one connector for two temperature measurements, one for two invasive blood pressure measurements, one for ECG, one for NIBP, and one for SpO_2 measurement. The NIBP connector includes two plungers for NIBP hose identification. The keys are for NIBP Auto On/Off, NIBP Start/Cancel, P1 zero, and P2 zero.

2.2.2 NIBP board

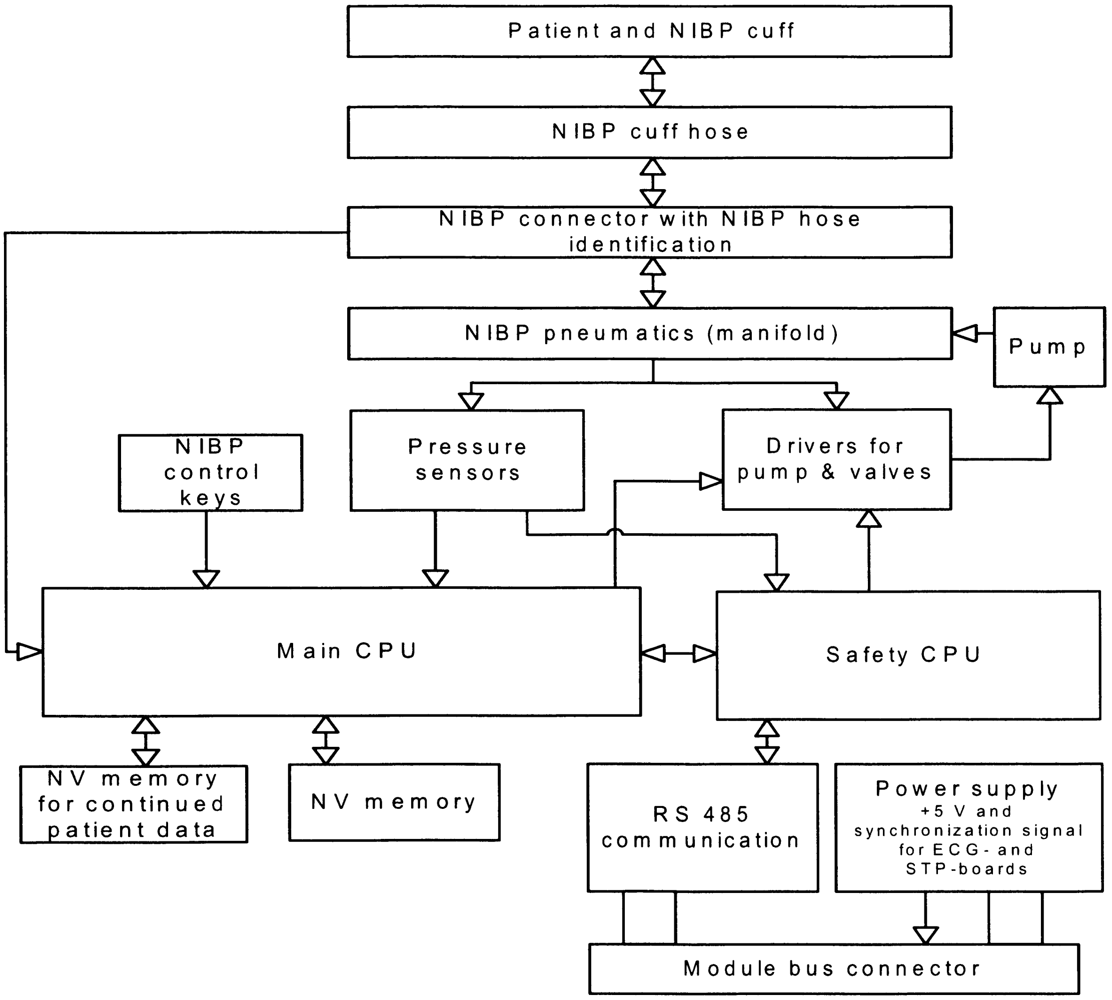

Patient and NIBP cuff
NIBP cuff hose
NIBP connector with NIBP hose identification
NIBP pneumatics (manifold)
Pump
NIBP control keys
Pressure sensors
Drivers for pump & valves
Main CPU
Safety CPU
NV memory for continued patient data
NV memory
RS 485 communication
Power supply +5 V and synchronization signal for ECG- and STP-boards
Module bus connector

Figure 5 **NIBP board functional block diagram**

Signal processing

Two signals from the pressure transducers are amplified and sent to the A/D converter. After the converter, digitized signals are sent to the microprocessor for data processing.

The NIBP board is controlled with an H8/3052 microprocessor at 16 MHz oscillator frequency.

Memory

The NIBP program memory (processor flash memory) size is 512k x 8. The processor has 4 kBytes RAM and there is also an external RAM memory, the size of which is 128k x 8. Variable values of the NIBP measurement are stored into the external RAM. The EEPROM size is 512 x 8 and it is used to store the calibration values for the pressure transducers, the pulse valve constants gained during measurements, the PC board identification, and the module serial number.

Software control

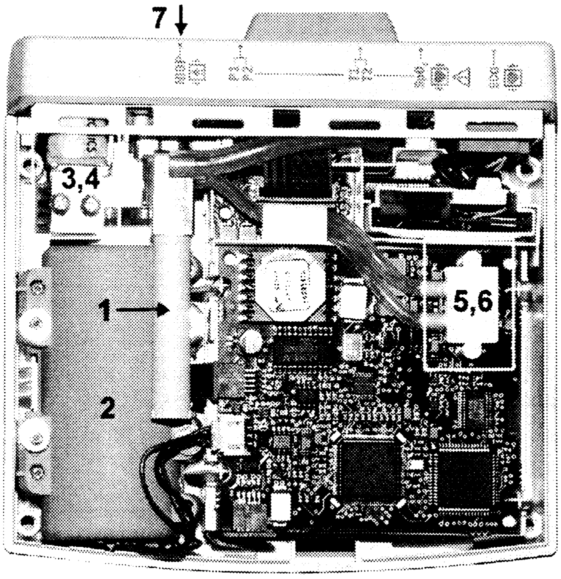
The software controls valves and a pump. In addition to the individual on/off signals for each component there is a common power switch for the valves and the pump that can be used at pump/valve failures.

In addition to external RS485 reset line, the microprocessor system is equipped with its own power-up reset. See the section in the ECG board's description: "RS485 communication"

Safety circuit

The NIBP board is equipped with an independent safety circuit to disconnect supply voltages from the pump and the valves if the cuff has been pressurized longer than the preset maximum measurement time, or if the pressure of the cuff is inflated over the specified pressure limit. The maximum measurement time values and pressure limits for different measurement modes have been specified in the technical specification section of this manual.

Pneumatics



The module has the following pneumatics parts:

1. **Intake air filter**; for preventing dust and other parts from entering the air pump and the valves.
2. **Air pump**; for pumping the measuring pressure of the cuff.
3. **(Pulse) Valve**; for producing a linear pressure fall (bleeding) in order to measure the blood pressure of the patient.
   Note that in the service menu also names **Valve** and **Set valve** have been used for this valve.
4. **Safety valve**; The safety valve is intended to be used for deflating the cuff in single fault case, i.e. to prevent too long a measurement time or too high an inflation pressure of the cuff.
   Note that lso **Exh2 valve** has been used to designate the **Safety valve** in service menu.
5. **Main pressure sensor**; for measuring the pressure of the blood pressure cuff and the pressure fluctuations caused by arterial wall movement.
6. **Safety pressure sensor;** for detecting the cuff loose, cuff occlusion situations, etc. and for recognizing the pressure sensor fault.
7. **Cuff connector;** for connection and hose identification.

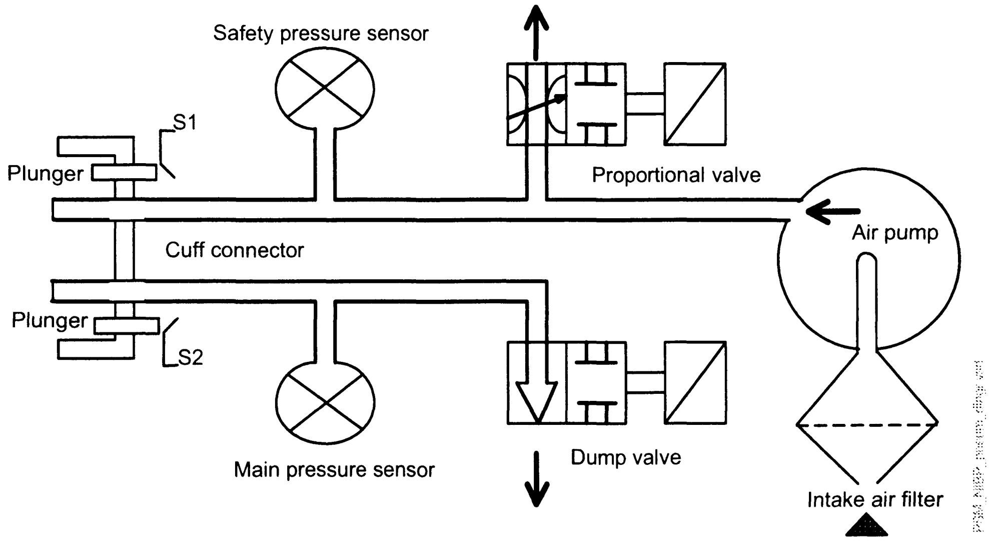

Safety pressure sensor
S1
Plunger
Proportional valve
Air pump
Cuff connector
Plunger
S2
Main pressure sensor
Dump valve
Intake air filter

Figure 6 **NIBP pneumatics diagram**

Power supply section of the NIBP board

All connections are established via a 5-pin connector (female). The module needs a +15 V (dirty) power supply to operate. The supply voltage Vmod 13.8- 16 V is generated in the power supply section of the monitor. The other voltages needed for the operation of the NIBP measurement are made on the NIBP board.

The NIBP power supply synchronizes the ECG and STP isolation power and supplies non-isolated 5 V to the ECG and STP board.

2.2.3 ECG board in 12-lead measurement

The 12-lead ECG measurement consists of the functions shown in Figure 7 on page 16. All functions are located in the ECG board except the ECG input unit.

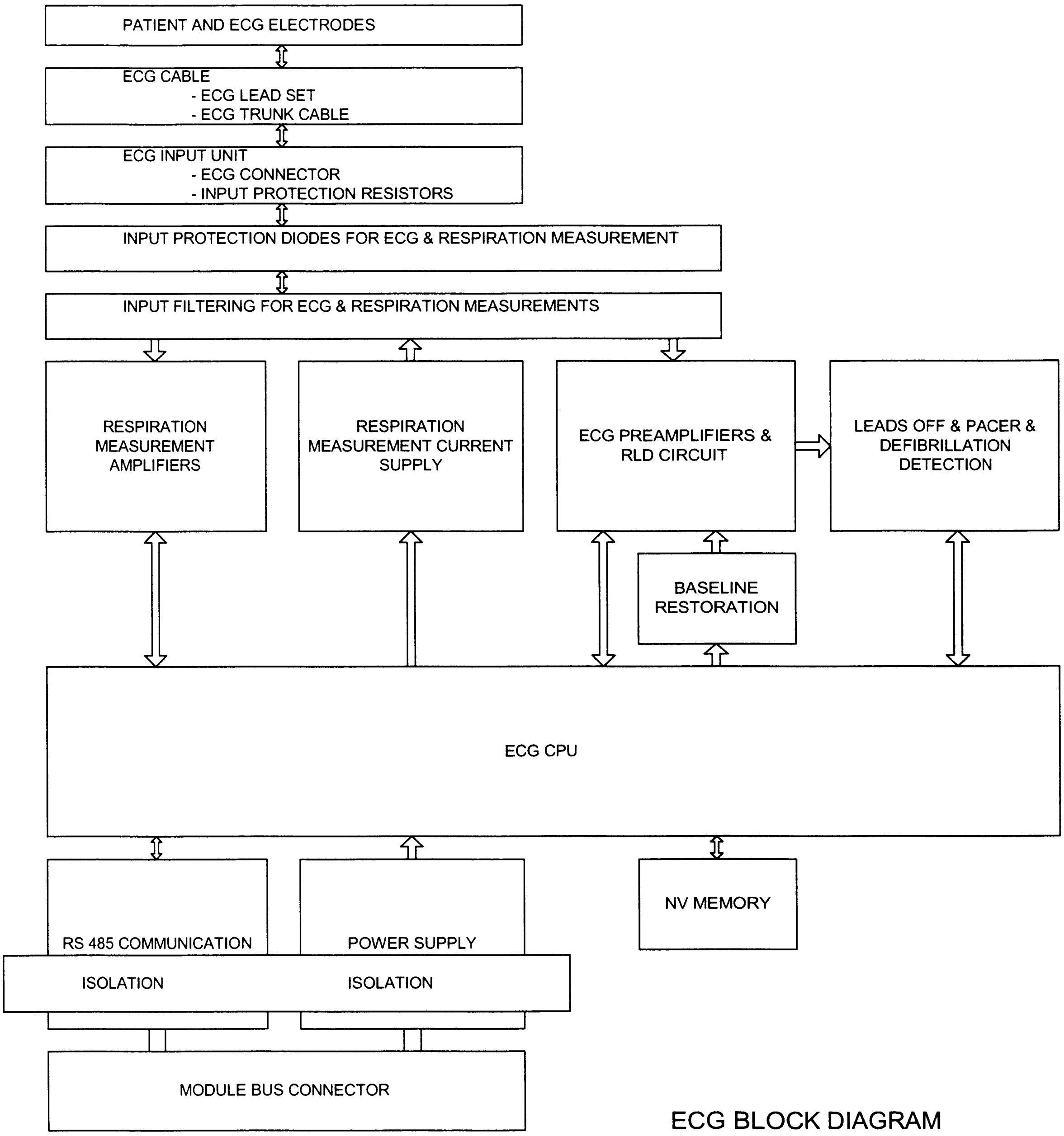

PATIENT AND ECG ELECTRODES
ECG CABLE
- ECG LEAD SET
- ECG TRUNK CABLE
ECG INPUT UNIT
- ECG CONNECTOR
- INPUT PROTECTION RESISTORS
INPUT PROTECTION DIODES FOR ECG & RESPIRATION MEASUREMENT
INPUT FILTERING FOR ECG & RESPIRATION MEASUREMENTS
RESPIRATION MEASUREMENT AMPLIFIERS
RESPIRATION MEASUREMENT CURRENT SUPPLY
ECG PREAMPLIFIERS & RLD CIRCUIT
LEADS OFF & PACER & DEFIBRILLATION DETECTION
BASELINE RESTORATION
ECG CPU
RS 485 COMMUNICATION
POWER SUPPLY
NV MEMORY
ISOLATION
ISOLATION
MODULE BUS CONNECTOR
ECG BLOCK DIAGRAM

Figure 7 **12-lead ECG measurement block diagram**

ECG input unit

The ECG input unit consists of the front panel connector and the ECG input connector board with the high voltage protection resistors. The connector for the 12-lead ECG cable is a green 11-pin rectangle shaped connector.

Input protection and filtering

The input protection is implemented with high voltage protection resistors in the ECG input unit and with protection diodes in the ECG board. The input filtering for ECG measurement is done with passive RC filtering.

ECG preamplifiers

The buffer amplifiers are used for each lead. The "Leads off" detection is implemented by measuring the output level of the input buffer amplifiers with the A/D converter of the CPU. The ECG signals are measured using differential amplifiers.

ECG amplifiers and baseline restoration

The function of the ECG amplifiers and baseline restoration is to amplify the signal and to restore the baseline of the signal in the middle of the display after the change of the signal level, e.g. after the change of the DC offset voltage.

Pacer detection

Pacer detection has been made by using four slew rate detector circuits. The pacer detection amplifiers have been realized at the front of the slew rate detectors independently of the ECG measuring channels.

Respiration impedance supply

The 31.25 kHz sine wave generator is used as the respiration measurement signal supply. Analog switches are used for connecting the sine wave to the ECG leads to be measured.

Respiration impedance amplifiers

Buffer amplifiers are used in respiration measurement. Analog switches are used for selecting the measurement leads. There are also additional amplifiers for increasing the respiration signal gain. When ECG measurement is 5/12-lead, the respiration measurement is always done between R and F, independently on the ECG lead selection. When ECG measurement is 3-lead, then the respiration measurement is happened at the same lead as the ECG measurement (I, II or III).

ECG CPU

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

RS485 communication

The communication to the CPU board of the monitor uses RS485 protocol. The RS485 driver circuits are optically isolated from the processor of the module.

Power supply

The ECG board has a driver-controlled half-bridge switching power supply with 5 kV isolation. The supply voltages have been regulated with linear regulators.

2.2.4 ECG filtering

Datex-Ohmeda S/5 monitors have three ECG filtering modes:

MONITORING	0.5 to 30 Hz (with 50 Hz reject filter) 0.5 to 40 Hz (with 60 Hz reject filter)
DIAGNOSTIC 12-lead ECG	0.05 to 150 Hz
ST FILTER	0.05 to 30 Hz (with 50 Hz reject filter) 0.05 to 40 Hz (with 60 Hz reject filter)

The purpose of filtering is to reduce high frequency noise and low frequency (e.g. respiratory) movement artifacts.

The monitor filter is used in normal monitoring. The diagnostic filter is used if more accurate diagnostic information is needed. The ST filter gives more accurate information of ST segment, but reduces high frequency noise.

The high-pass filters 0.5 Hz and 0.05 Hz are done with software. The monitor sends a command to the hemodynamic module determining which of the corner frequencies 0.5 Hz or 0.05 Hz is to be used.

The 50 Hz and 60 Hz reject filters are both low-pass filters with zero at 50 Hz or 60 Hz correspondingly. They are software based filters used for the mains supply filtering. With these filters the 3 dB value for low-pass filter is 30 Hz or 40 Hz.

In diagnostic mode the upper frequency is 150 Hz and it is limited by software.

2.2.5 STP board

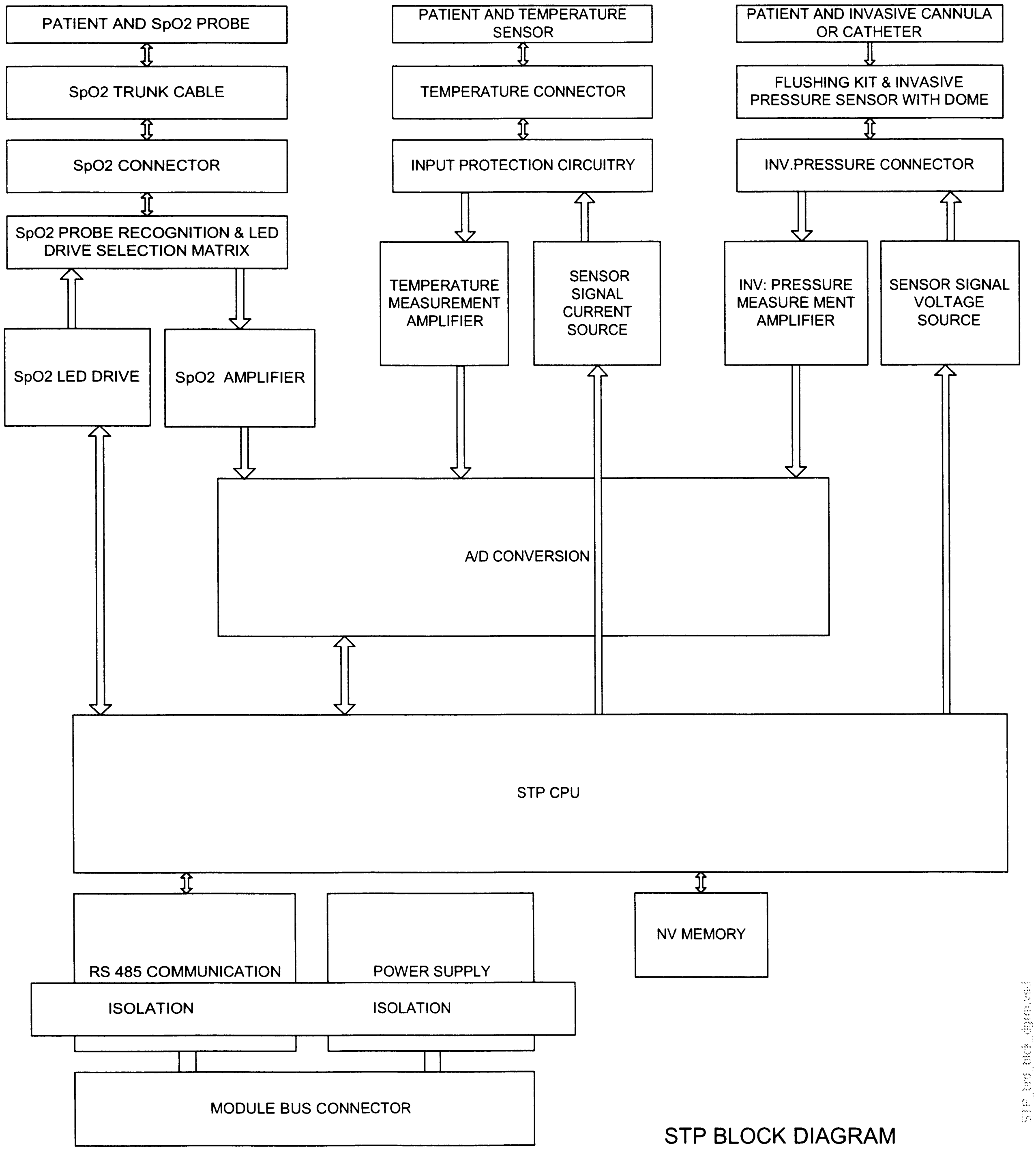

PATIENT AND SpO2 PROBE
SpO2 TRUNK CABLE
SpO2 CONNECTOR
SpO2 PROBE RECOGNITION & LED DRIVE SELECTION MATRIX
SpO2 LED DRIVE
SpO2 AMPLIFIER
PATIENT AND TEMPERATURE SENSOR
TEMPERATURE CONNECTOR
INPUT PROTECTION CIRCUITRY
TEMPERATURE MEASUREMENT AMPLIFIER
SENSOR SIGNAL CURRENT SOURCE
PATIENT AND INVASIVE CANNULA OR CATHETER
FLUSHING KIT & INVASIVE PRESSURE SENSOR WITH DOME
INV.PRESSURE CONNECTOR
INV: PRESSURE MEASURE MENT AMPLIFIER
SENSOR SIGNAL VOLTAGE SOURCE
A/D CONVERSION
STP CPU
RS 485 COMMUNICATION
POWER SUPPLY
NV MEMORY
ISOLATION
ISOLATION
MODULE BUS CONNECTOR
STP BLOCK DIAGRAM

Figure 8 STP board block diagram

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain a pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about 38 μA current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the STP board through an A/D converter.

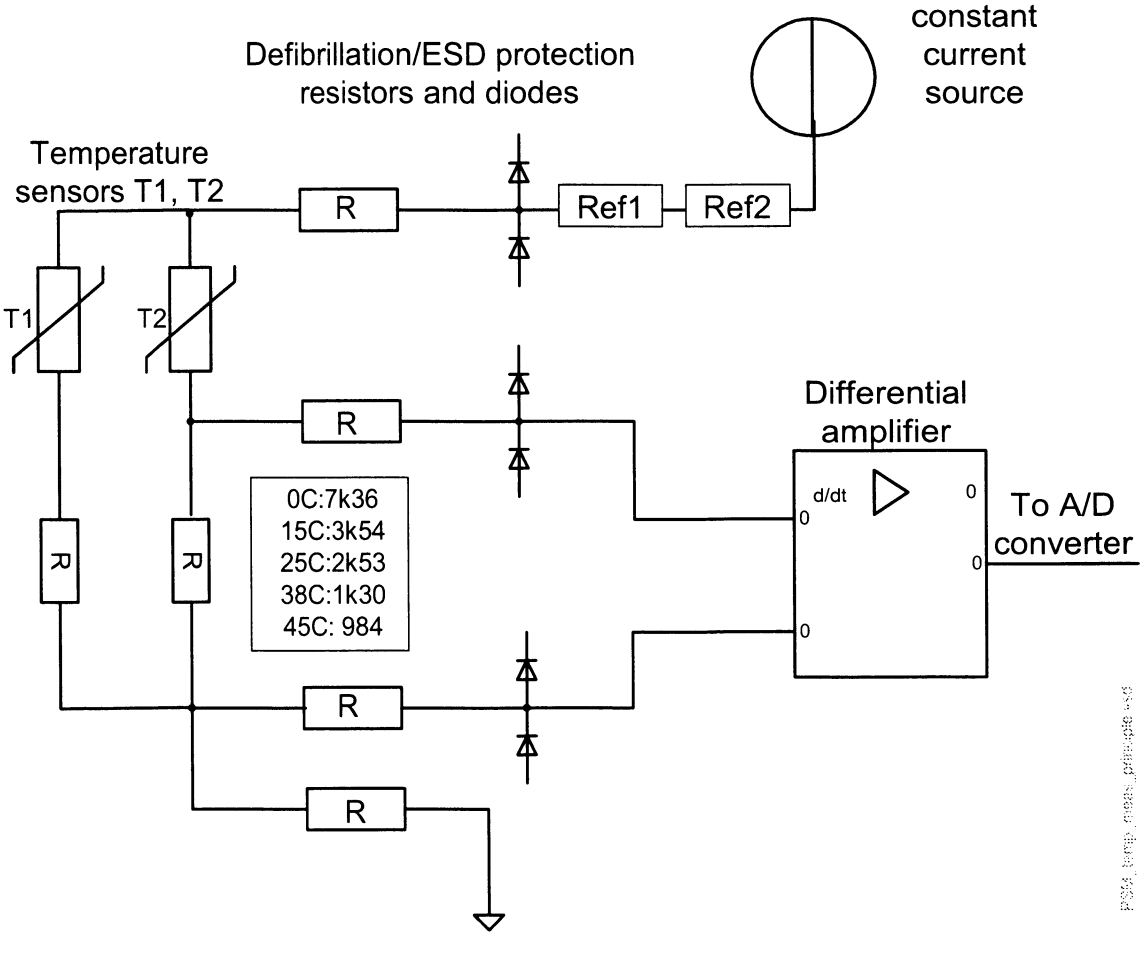

Defibrillation/ESD protection resistors and diodes
constant current source
Temperature sensors T1, T2
R
Ref1
Ref2
T1
T2
R
Differential amplifier
d/dt
0
0
0
0
0
To A/D converter
0C:7k36
15C:3k54
25C:2k53
38C:1k30
45C: 984
R
R
R
R

Figure 9 **Temperature measurement principle**

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to the A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

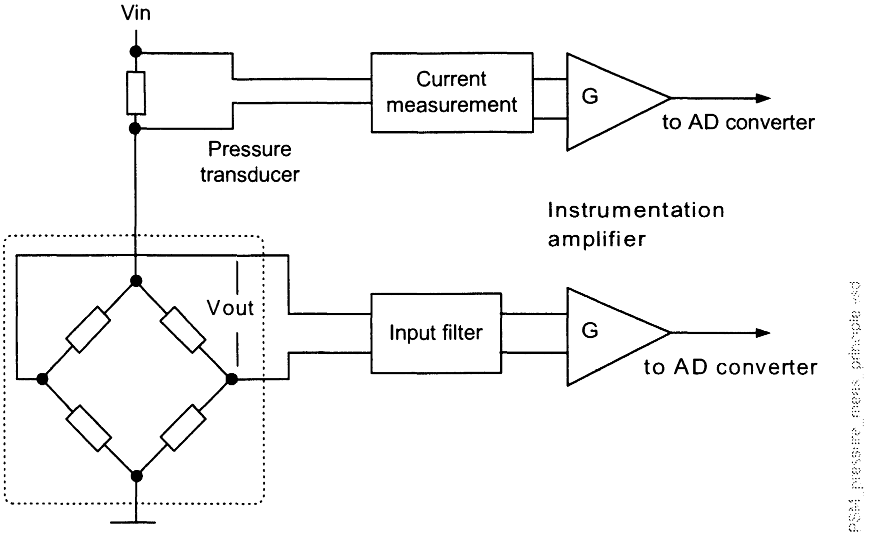


Figure 10 Pressure measurement principle

Pulse oximetry measurement section

LED control signals

The D/A converters of the microcontroller on the STP board set the LED intensity adjustment values for the infrared and red LEDs of the SpO_2 probe. The microcontroller on the STP board switches ON (to the adjusted intensity) and OFF the SpO_2 probe LEDs according to the predetermined sequence.

LED driving circuit

Differential amplifiers measure the LED currents (LED current indication) of the SpO_2 probe over the shunt resistors placed in the LED current paths. The LED driving voltages (LED voltage indication) are measured from the driver circuitry. The LED driving circuits also have MOSFET transistor matrix to enable the use of different probe configurations.

Measured signal preamplification

The preamplifier is a bipolar/single-ended current-to-voltage converter with adjustable gain. A higher gain is used for measuring thin tissue. The preamplification stage has also ambient light reduction and a second amplifier stage.

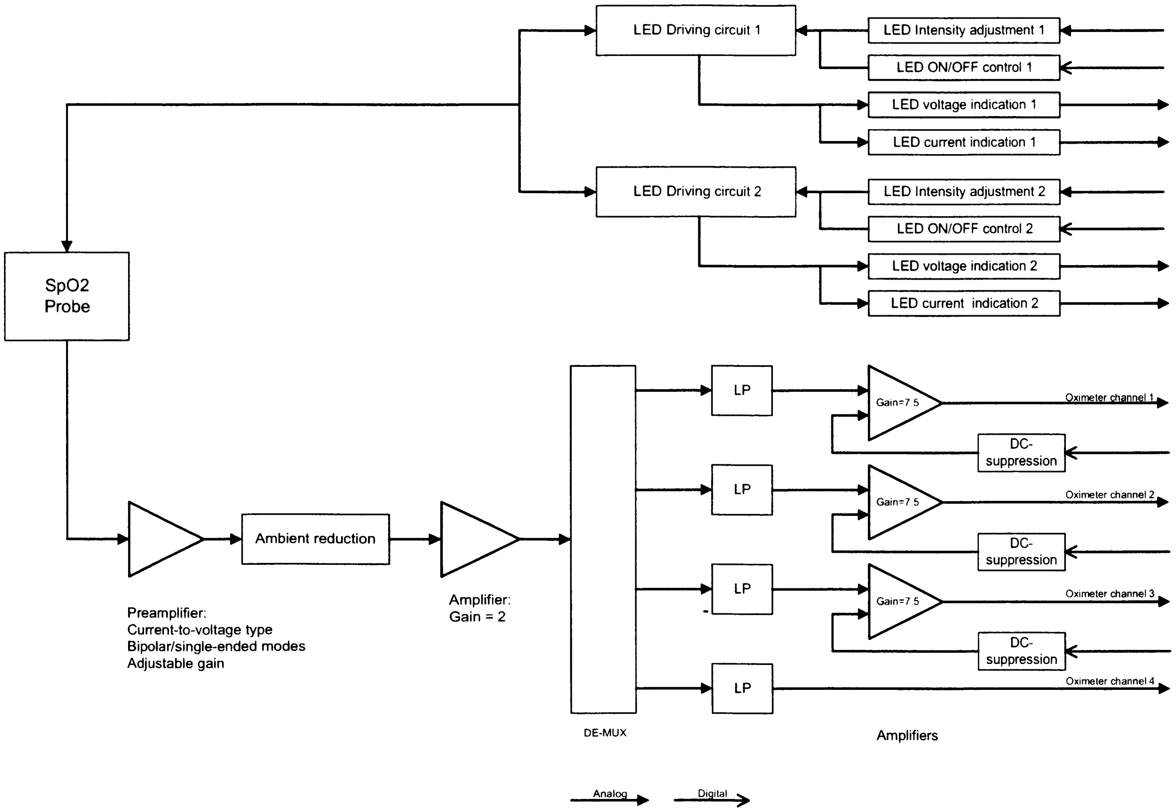

LED Driving circuit 1
LED Intensity adjustment 1
LED ON/OFF control 1
LED voltage indication 1
LED current indication 1
LED Driving circuit 2
LED Intensity adjustment 2
LED ON/OFF control 2
LED voltage indication 2
LED current indication 2
SpO2
Probe
Ambient reduction
Preamplifier:
Current-to-voltage type
Bipolar/single-ended modes
Adjustable gain
Amplifier:
Gain = 2
LP
LP
LP
LP
DE-MUX
Gain=7.5
Gain=7.5
Gain=7.5
DC-
suppression
DC-
suppression
DC-
suppression
Oximeter channel 1
Oximeter channel 2
Oximeter channel 3
Oximeter channel 4
Amplifiers
Analog
Digital

Figure 11 **Pulse oximetry measurement block diagram**

Red and infrared channel separation

It is possible to multiplex the detector signal to four different channels depending on the content of the signal. The detector signal must at least multiplex into infrared and red signals. Other channels are e.g. for diagnostic purposes.

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. The data transmission rate is 500kbps.

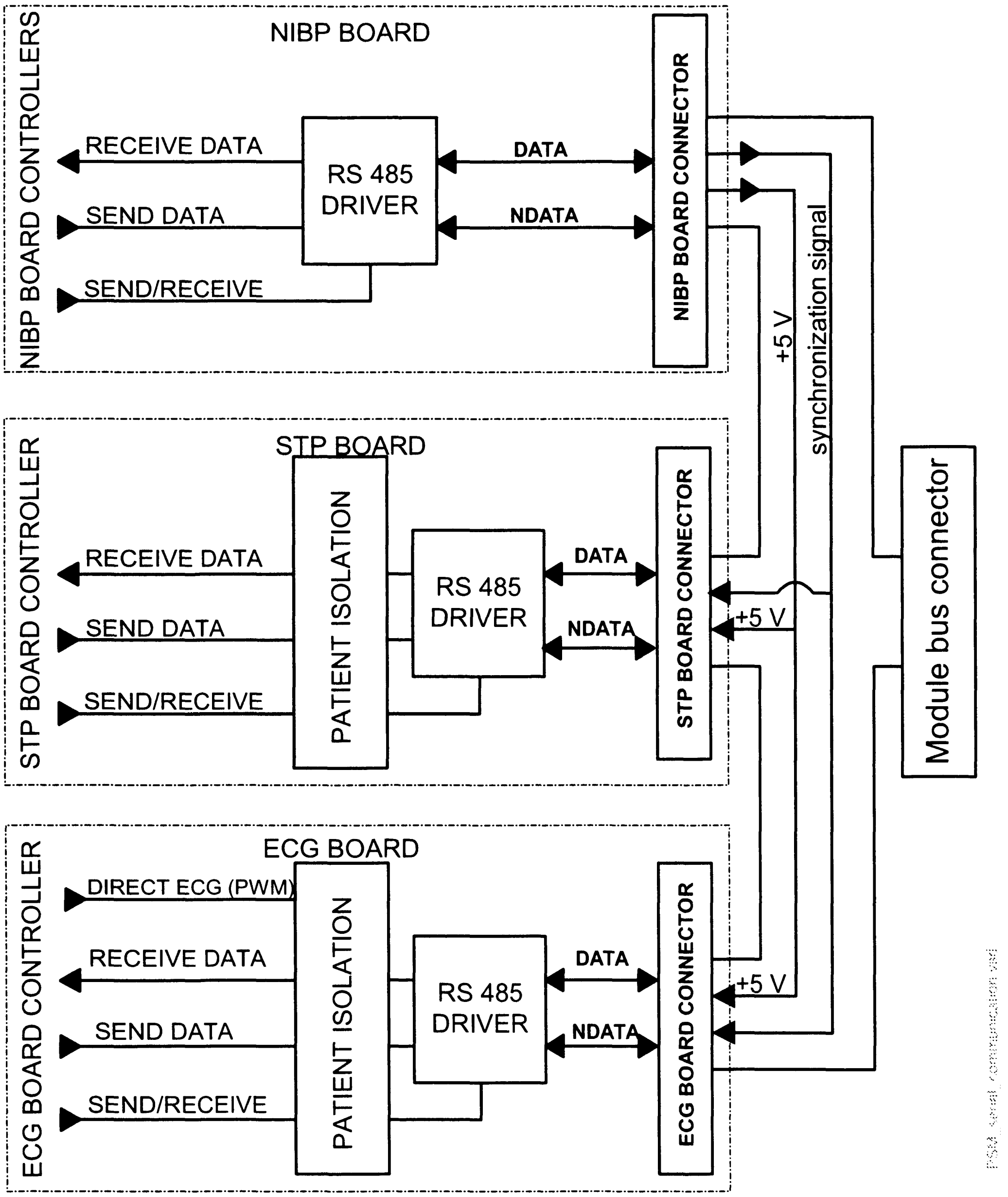

NIBP BOARD CONTROLLERS
NIBP BOARD
RECEIVE DATA
SEND DATA
SEND/RECEIVE
RS 485 DRIVER
DATA
NDATA
NIBP BOARD CONNECTOR
+5 V
synchronization signal
STP BOARD CONTROLLER
STP BOARD
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
STP BOARD CONNECTOR
+5 V
Module bus connector
ECG BOARD CONTROLLER
ECG BOARD
DIRECT ECG (PWM)
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
ECG BOARD CONNECTOR
+5 V
PSM serial communication.vsd

Figure 12 Serial communication of E-PSM(P) module

Signals and isolation barrier

The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

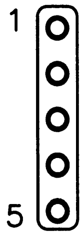
Power supply section

The power for the electronics on the floating part of the STP and the ECG boards is made on each board with the switching power supplies connected to a high voltage isolated transformer. The switching power supplies on the STP and ECG boards are synchronized to the frequency, about 340kHz of the switching power supply on the NIBP board. The NIBP board supplies non-isolated 5 V to the ECG and STP boards. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. Each measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Table 8 Module bus connector description

5 pin female connector	Pin No.	Signal
	1 2 3 4 5	GND Vmod 13.8 - 16 V Data + Data - Shield

2.3.2 Front panel connectors

Table 9 ECG connector

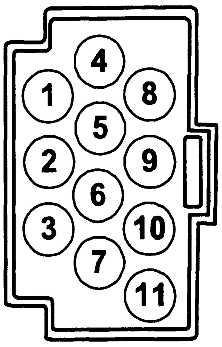
ECG Connector	Pin No.	Signal Name
	1	R/RA; Right arm electrode
	2	C2/V2; Chest electrode
	3	C3/V3; Chest electrode
	4	L/LA; Left arm electrode
	5	N/RL; Neutral/Right Leg Drive electrode
	6	C1/V1; Chest electrode
	7	C4/V4; Chest electrode
	8	F/LL; Left Leg electrode
	9	C6/V6; Chest electrode
	10	C5/V5; Chest electrode
	11	Cable Shield

Table 10 SpO_2 connector

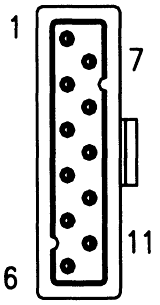
SpO_2 connector	Pin No.	Signal	Description
	1	DET_A	Photodiode anode
	2	DET_C	Photodiode cathode
	3	DATA-	
	4	Wire 1/3	LED connection
	5	IR_C	IR LED cathode
	6	OUTER SHIELD	
	7	DET_SHIELD	
	8	PRB_ID	Bin/ID Resistor+
	9	Wire 3/5	LED Connection
	10	RED_C	RED LED cathode
	11	DATA+	

Table 11 Invasive blood pressure connectors (P1, P2)

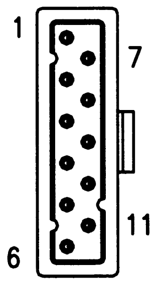
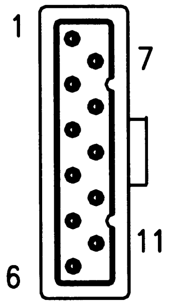
Invasive blood pressure connectors (Dual BP)	Pin No.	Signal	Description
	1	BP_+VREF	BP transducer excitation voltage, channel 1
	2	BP SIG+	BP transducer signal positive (+), channel 1
	3	BP_+VREF	BP transducer excitation voltage, channel 2
	4	AGND	Analog ground
	5	BP SIG+	BP transducer signal positive (+), channel 2
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-), channel 1
	9	BP SIG2	BP transducer signal negative (-), channel 2
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

Table 12 Temp connector (T1, T2)

Temp connector (T1, T2)	Pin No	Signal
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Not connected
	11	Digital ground

3 Service procedures

3.1 General service information

The field service of the hemodynamic modules is limited to replacing faulty printed circuit boards or mechanical parts. The circuit boards should be returned to Datex-Ohmeda for repair.

Datex-Ohmeda is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair, Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Table 13 Recommended tools

Tool	**Order No.**	**For product(s)**
Hemodynamic patient simulator	M1010831	Hemodynamic modules
Adapter cables for simulators		
- Dual temperature adapter cable	402015-004	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Pressure manometer		Hemodynamic modules w/ (P)
Accessories:		
Temperature test set	884515	Hemodynamic modules w/ (T)
Multi-Link ECG accessories, IEC:		
- Multi-link 3-leadwire set	412682-003	Hemodynamic modules w/ (E)

Tool	Order No.	For product(s)
- Multi-link 5-leadwire set	412681-003	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, C2-C6	416467-004	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-002	Hemodynamic modules w/ (E12)
Multi-Link ECG accessories, AHA:		
- Multi-link 3-leadwire set	412682-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set	4162681-001	Hemodynamic modules w/ (E)
- Multi-link 5-leadwire set, V2-V6	416467-003	Hemodynamic modules w/ (E)
- Multi-link 12-lead ECG trunk cable	416035-001	Hemodynamic modules w/ (E12)
SpO$_2$ finger probe	OXY-F-UN	Hemodynamic modules w/ (S)
SpO$_2$ Interconnect Cable	OXY-ES3	Hemodynamic modules w/ (S)
InvBP transducer	70077-001	Hemodynamic modules w/ (P)
Adult NIBP cuff hose with cuff ID	2021285-001	Hemodynamic modules w/ (NIBP)
Infant cuff hose without cuff ID	414874-001	Hemodynamic modules w/ (NIBP)
Screwdriver		

3.2.2 Recommended parts

Table 14 Recommended parts

Part	Order No.	Notes
NIBP pump filter	57142	

3.2.3 Visual inspection

Detach the module cover by removing the four screws from the bottom of the module.

Check:

1. Internal parts
   - screws are tightened properly
   - connectors are connected properly
   - NIBP tubing is attached properly
   - there are no loose objects inside the module

2. External parts
   - the front cover and the front panel sticker are intact
   - all connectors are intact and attached properly

– the module box and latch are intact

3.2.4 Functional inspection

3. NIBP pump filter

   Replace the NIBP pump filter, if necessary.

   Reattach the module cover and check that the latch is moving properly.

   Switch the monitor on and wait until the monitoring screen appears. Configure the monitor screen so that all the needed parameters are shown, for example as follows:

   Monitor Setup - ***Waveform Fields - Field 1 - ECG1***
   Field 2 - ECG2
   Field 3 - P1
   Field 4 - P2
   Field 5 - Pleth
   Field 6 - Resp
   Digit Fields - Lower Field 2 - NIBP
   Lower Field 3 - T1+T2

4. Module installation

   Plug in the module. Check that it goes in smoothly and locks up properly

5. Module recognition

   Check that the module is recognized, i.e. all the needed parameter information, except invasive blood pressure, starts to show on the screen.

   Preset ECG, Respiration, InvBP and SpO$_2$ measurement settings:

   ECG - ***ECG Setup - Hr Source - Auto***
   Pacemaker - Show

   Others - ***Resp Setup - Size - 1.0***
   Resp Rate Source - Auto
   Measurement - On
   Detection Limit - Auto

   Invasive Pressures - ***P1 'Art' Setup - Label - Art***
   P2 'Cvp' Setup - Label - Cvp

   Pulse Oximetry - ***Pleth Scale - Auto***

ECG measurement

6. Module software (serial numbers)

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) -
   Service (password 26-23-8)

   Take down the information regarding the module software by selecting ***Scroll Vers*** and turning the ComWheel.

   ✍

7. Communication and memories

   Enter the ***Parameters - ECG*** service menu.

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the ECG/RESP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM state all OK.

   ✍

8. Power frequency

   Check that the power frequency value is set according to the current mains power frequency. Change the setting by selecting ***Power Freq***, if necessary.

   ✍

9. Cable recognition

   Connect a 12-lead ECG trunk cable without a lead set to the module. Check that the message 'Leads off' is displayed on the screen.

   ✍

10. Lead detection

    Connect both 5-leadwire sets to the trunk cable. Connect limb lead electrodes and one electrode from the chest lead set to the same potential. Check that the Cable type shows 10 lead.

    Change the 3-leadwire set to the trunk cable. Check that all the electrodes show OFF in the service menu and the message 'Leads Off' is shown on the screen.

    Connect all the leads together, for example to a suitable screwdriver. Check that all the electrodes show ON and the message 'Asystole' appears.

    Disconnect one of the leads and check that the corresponding electrode in the service menu shows OFF within 10 seconds of the disconnection, and then reconnect the lead. Check the rest of the leads using the same method.

    NOTE: When any of the limb leads is disconnected, the measurement will automatically change to 3 electrode ECG measurement.

    NOTE: The asystole and different leads off messages are shown using certain priority, Even though one of the leads is disconnected, the related leads off message may not appear on the screen.

NOTE: When RA, LA , LL or RL electrode is disconnected, all six V electrodes show OFF.

11. Test with the patient simulator

    Connect the leads to a patient simulator.

    Perform the settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    ECG - BASE - BPM - 160
    PACE - WAVE - NSR

    Check that a normal ECG waveform is shown, the HR value is 160 (±5) and the 'Pacer count' -value is not increasing in the service menu.

    ECG - PACE - WAVE - ASNC

    Check that pacemaker spikes are shown on the ECG waveform, the HR value changes to 75 (±5) and the Pacer count value is increasing according to the shown pacemaker spikes.

    Set the pacemaker option off:

    ECG - PACE - WAVE - NSR

Respiration measurement

12. RESP measurement recognition

    Check that Resp Available and RESP Measurement both show ON in the ESTP: ECG service menu.

13. Test with patient simulator

    Check the respiration measurement with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    BASELINE IMPEDANCE -switch - 500
    LEAD SELECT-switch - II/RL-LL

    RESP - WAVE - NORM
    RATE - 20
    OHMS - 1.0
    RATIO - 1/1
    APNEA - OFF
    SHIFT - OFF

    Check that the RESP waveform is shown and the RR value is 20 (±5). Change the position of the BASELINE IMPEDANCE switch and check that appropriate RESP waveform and RR value are shown again within 30 seconds.

    RESP - APNEA - 32 S

    Check that the monitor activates the APNEA alarm.

    NOTE: Make sure that only the ECG leads are connected to the simulator during the apnea test. If other cables are connected at the same time, the respiration signal from the simulator may be disturbed, and therefore, the APNEA alarm may not be activated.

NOTE: When you have the ECG service menu open, spikes will appear on the respiration waveform. These spikes represent the threshold level for detecting inspiration and expiration.

✍

Temperature measurement

14. Communication and memories

    Enter the ESTP: STP service menu:

    Parameters - ESTP : STP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values do not increase faster than by 5 per second. Check also that the STP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

    ✍

15. Temperature probe detection

    Check that the 'Cable' and 'Probe' show OFF for both channels, T1 and T2, when no probes are connected.

    Connect the temperature adapter cable to the module temperature connector and a temperature test plug to the adapter cable. Check that the Cable and Probe for T1 show ON and the corresponding temperature value appears on the monitor screen.
    Perform the same check also for the channel T2.

    ✍

16. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more than 0.1 °C, calibrate the temperature channels according to the instructions in chapter "Temperature calibration" on page 47."

    ✍

17. Temp test

    Activate the temperature test by selecting ***Temp Test***. When the message 'Performing temp test' disappears from the digit field, check that no error messages appear and Temp error shows OFF for both channels in the service menu.

    ✍

18. Module configuration

    Check that the module configuration has been set correctly. The configuration in use is shown beside the text Configuration in the service menu and it can be either STP or ST. Change the configuration in the ***Calibrations - Set Config*** menu, if necessary. To activate the change, reset the module communication by removing and inserting the module.

    ✍

Invasive blood pressure measurement

19. Membrane keys

    Check the front panel membrane keys that are related to the InvBP measurement.

    Press each of the keys for at least one second. Check that the pressed key is identified, i.e. one of the texts for Buttons changes from OFF to ON in the service menu.

    ✍

20. Cable and transducer detection

    Check that the Cable and Probe for P1 show OFF. Connect the InvBP adapter cable to the module, connecta cable with an invasive blood pressure transducer to the adapter cable and check that the Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

    Perform the same check also for the InvBP channel P2.

    ✍

21. Calibration

    Calibrate the InvBP channels P1 and P2 according to the instructions in chapter "Invasive pressure calibration" on page 47."

    ✍

22. Test with patient simulator

    Check the InvBP channels with a patient simulator.

    The settings and checks with Dynatech Nevada MedSim 300 Patient Simulator:

    SENSITIVITY - switch - 5 µV/V/mmHg

    ECG - BASE - BPM - 60 - BP - 1 - WAVE - ATM
    2 - WAVE - ATM

    Restore the normal monitoring screen by pressing the key **Normal Screen**.

    Connect cables from the channels BP1 and BP2 to the module connectors. Zero the InvBP channels by pressing the keys ZERO P1 and ZERO P2 on the module front panel.

    BP - 1 - WAVE - ART
    2 - WAVE - CVP

    Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 120/80 (±3 mmHg) for the channel P1 and 15/10 (±2 mmHg) for the channel P2.

    Check that the HR value is calculated from P1, when ECG is not measured (ECG cable disconnected).

    ✍

SpO$_2$ measurement

23. SpO$_2$ probe detection

    Check that the message 'No probe' is shown, when no SpO$_2$ sensor is connected to the module. Connect an SpO$_2$ finger probe to the module (with the interconnection cable, if needed). Check that the message 'Probe off' is shown when the probe is not connected to a finger.

24. Test measurement

    Connect the SpO$_2$ probe onto your finger. Check that the reading of 95-99 and SpO$_2$ waveform appears. Check that the HR value is calculated from SpO$_2$ when ECG and InvBP (P1) are not measured.

Non Invasive Blood Pressure measurement

25. Communication and memories

    Enter the NIBP module service menu:

    Parameters - NIBP

    Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the NIBP board memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

26. Membrane keys

    Check the front panel membrane keys.

    Select ***Buttons/Leds***.

    Press each of the two NIBP related membrane keys for at least one second. Check that the pressed key is identified, i.e. the corresponding text changes from OFF to ON in the menu, when the key is released back up again.

27. Pump and valves

    Check the pump and valves.

    Select ***Pneumatics*** from the NIBP menu. Connect a pressure manometer to the NIBP module cuff connector.

    Select ***Start Pump*** and press the ComWheel. Check that the pump turns on and the pressure inside the tubing system starts to increase. Stop the pump by pressing the ComWheel again when the pressure reaches 280 mmHg.

    Select ***Open Exh2***. Press the ComWheel and check that the pressure inside the tubing system starts to drop, then press the ComWheel again. If necessary, turn the pump on again for a moment to increase the pressure inside the tubing system.

Select ***Set Valve***. Press the ComWheel and set the value under the text Pulse Valve to number 150 by turning the ComWheel. Press the ComWheel again and check that the pressure inside the tubing system starts to drop. Finish the test by selecting ***Previous Menu***.

28. Leak test

    Check the NIBP tubing system for leakages.

    Select ***Calibrations*** from the NIBP service menu.

    Connect the pressure manometer to the NIBP module cuff connector. Start the active leak test from the menu by pressing the ComWheel. The module pumps a pressure of about 265 mmHg and then the pump stops.

    Wait for 15 seconds for the pressure to stabilize then check that the pressure does not drop more than 6 mmHg per one minute. Release the pressure by pressing the ComWheel once more.

29. Calibration check

    Recalibrate the NIBP measurement according to the instructions in chapter "NIBP calibrations" on page 45. Remember to set the calibration protection back on after the calibration.

    Disconnect the pressure manometer. Select ***Calibrations*** - ***Calibration Check***. Press the ComWheel and take down the zero offset values for both pressure transducers, B1 and B2. The values should be within ±20 mmHg.

    Connect the pressure manometer to the cuff connector and check the calibration with pressures 100 mmHg, 200 mmHg and 260 mmHg. The zero offset value must be added to the displayed pressure value in order to determine the real pressure.

30. Safety valve functions

    Select ***Safety Valve*** from the NIBP service menu.

    Keep the pressure manometer connected to the cuff connector.

    NOTE: Make sure your pressure manometer can be used to measure pressures over 300 mmHg. If such a pressure manometer is not available, perform the check with an adult cuff that is connected around some round object, for example a calibration gas bottle.

    Select ***Start Test***. Start the adult safety valve test by pressing the ComWheel. Wait until the pump stops and the pressure is deflated. Check the pressure values 'Max press' and '2 s after stop' for both transducers. All the values should be within 270 - 330 mmHg.

    Select ***ADULT***. Press the ComWheel and check that the text changes now to ***INFANT***. Select ***Start Test*** and wait until the pump stops and the pressure values on the screen have been updated. Check that the values 'Max press' and '2 s after stop' are all now within 135 to 165 mmHg.

    Return to the normal monitoring mode by pressing **Normal Screen**.

31. Cuff related messages

    Connect an adult NIBP cuff to the cuff connector and disconnect one of its hoses.

Start NIBP measurement by pressing the key **Start/Cancel** on the module and check that the message 'Cuff loose' appears on the screen within 70 seconds.

Reconnect the hose and then bend it with your fingers. Restart the measurement and check that the message 'Cuff occlusion' appears on the screen within 70 seconds.

✍

32. Test measurement

Check that the automatic inflation limits are in use:

NIBP - ***NIBP Setup - Inflation Limits - Auto - Previous Menu***

Connect the cuff onto your arm, select ***Start Ven.Stasis*** in the NIBP menu and press the ComWheel. Check that the module identifies the cuff, i.e. the text Adult appears in the NIBP digit field for a short moment.
Keep the pressure inside the cuff for about half a minute in order to find out that the cuff is not leaking, then press the ComWheel again. Select **Normal Screen**.

Disconnect the cuff hose.

✍

33. NIBP hose detection

Press the **Start/ Cancel** module or side panel key and check that the 'Cuff loose' message appears in the NIBP digit field.
Attach a NIBP cuff hose without cuff identification and check that the module identifies the hose:

- The message 'Select inflation limits' appears in the NIBP digit field.
- When you try to start the measurement, the monitor automatically opens the selections ***NIBP Setup - Inflation Limits.***

✍

All modules

34. Electrical safety check

Perform an electrical safety check and a leakage current test.

✍

35. Functioning after electrical safety check

Check that the module functions normally after the performed electrical safety check.

✍

36. Final cleaning

Clean the module with suitable detergent.

✍

- Fill in all necessary documents.

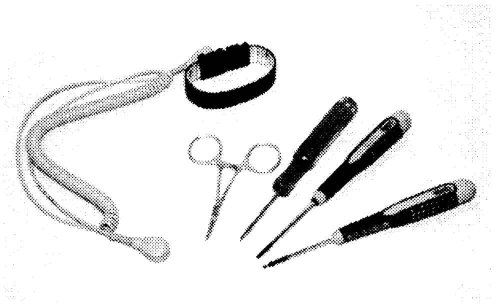
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

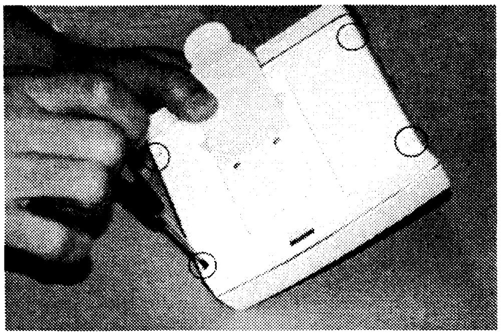
3.3.2 Tools needed



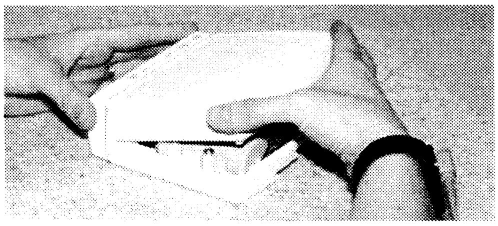
- torx screwdrivers; T6, T8
- flat blade screwdriver
- pincers
- antistatic wristband

CAUTION When reassembling the module, make sure that all cables are reconnected properly.

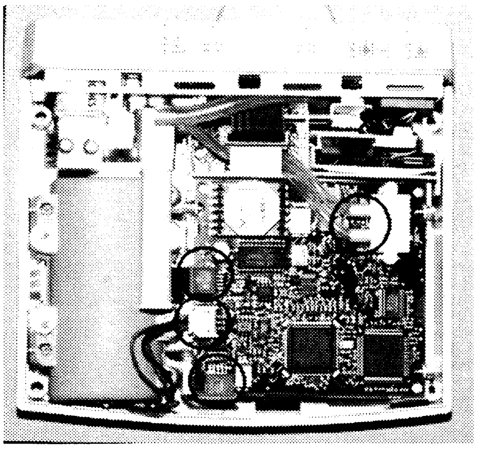
3.3.3 To disassemble the module



1. Remove the four screws (T8) holding the module cover to the frame from the bottom of the module.

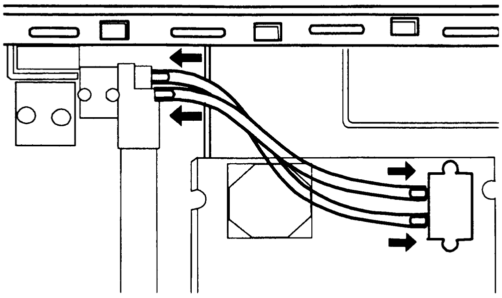


2. Hold the cover from the back corners, lift it about 45° to unlock the snaps from the front unit and pull the cover out backwards.



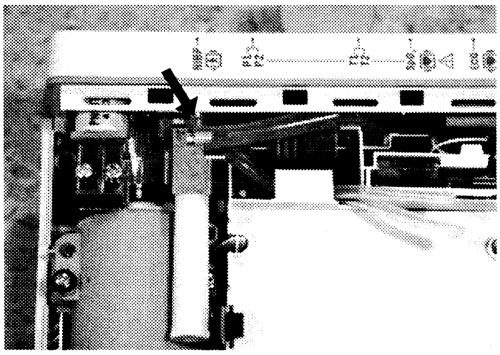
3. To remove the NIBP board:

- Disconnect the module bus connector, pump connector and NIBP flex connector.
- Disconnect the hoses (2 pcs) coming from the manifold.

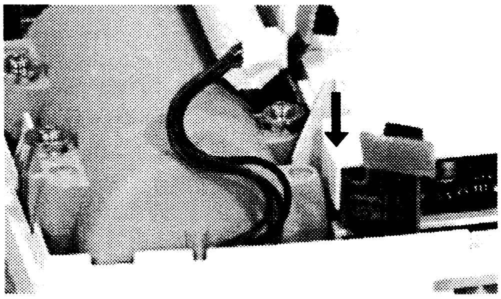


NOTE: Note the positions of the hoses; mark them if necessary to ensure they are replaced correctly.

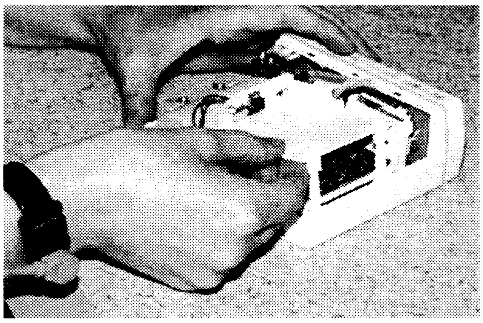
- Remove the NIBP board.



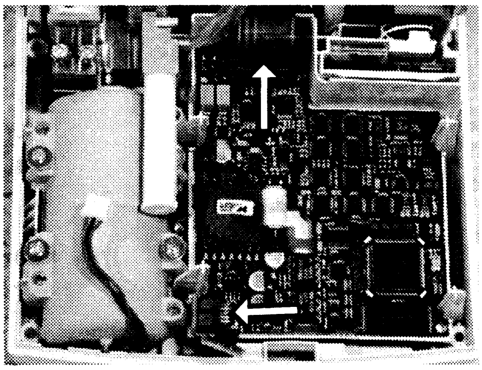
4. Disconnect the air intake hose from the NIBP manifold.



NOTE: The lips of the insulator plates secure the module bus connectors. While reassembling the insulator plates, ensure that the connector secure lips support the connectors correctly.

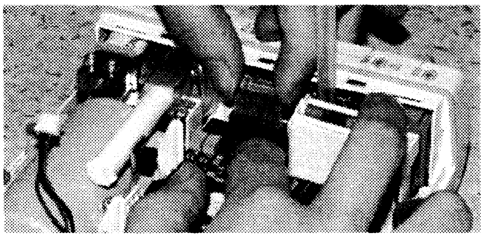


5. Lift the NIBP-STP insulator plate carefully up.

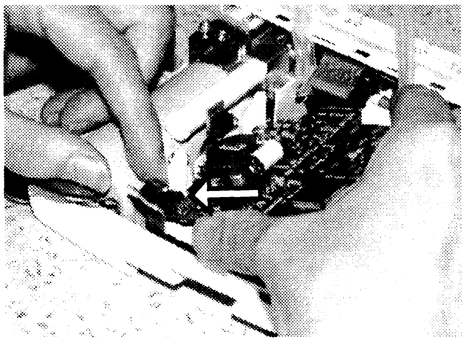


6. To remove the STP board

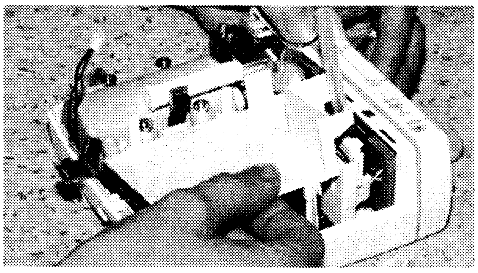
- Disconnect the STP input flex connector and the module bus connector.



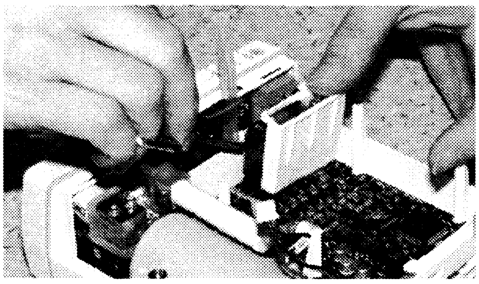
- Hold down the STP board while disconnecting the STP input flex connector.



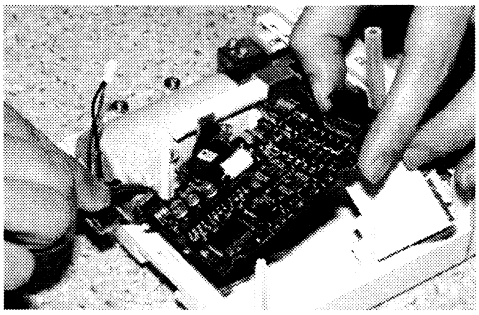
7. Lift the STP board a little to disconnect the module bus connector. Remove the STP board.



8. Remove the STP-ECG insulator plate. Be careful not to damage the NIBP hoses.

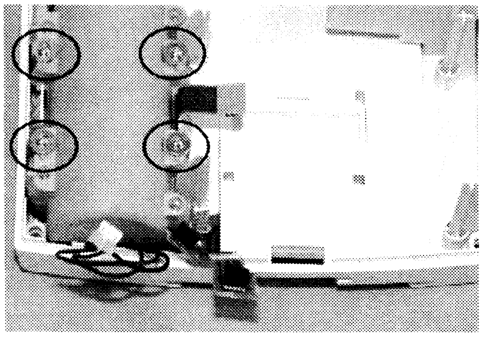


9. Hold down the ECG board for example by pressing the ECG input unit and use pincers to disconnect the ECG input flex connector from the ECG board.

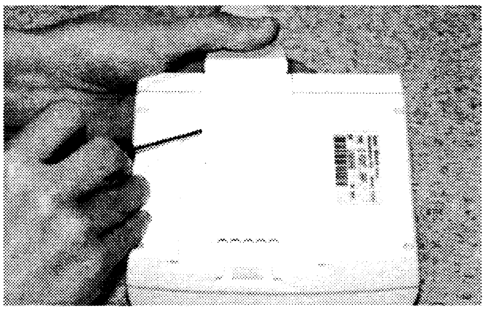


10. To remove the ECG board
   - While holding the ECG input unit out of the way, lift the ECG board a little and disconnect the module bus connector.
   - Remove the ECG board.

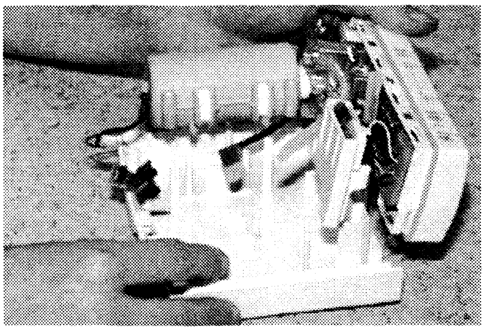
11. Remove the NIBP filter cover and the filter.



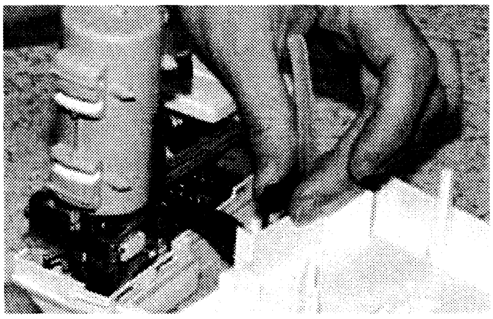
12. Remove the four screws (T6) with washers holding the NIBP pump to the frame.



13. Flip the module over and remove the two (T6) screws holding the lock unit to the frame. While pulling the tab push the lockers with a screwdriver to remove the lock unit.



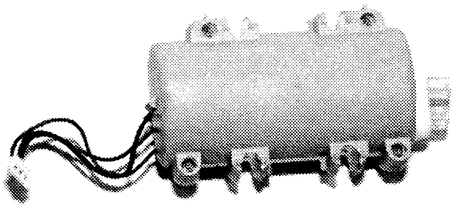
14. Carefully lift up the front unit together with the NIBP pump carefully.



15. To remove the front unit

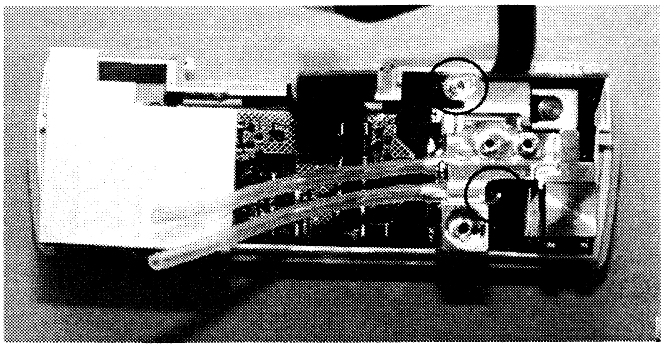
- Pull the flex board carefully downwards through the holder.

To remove the pump unit

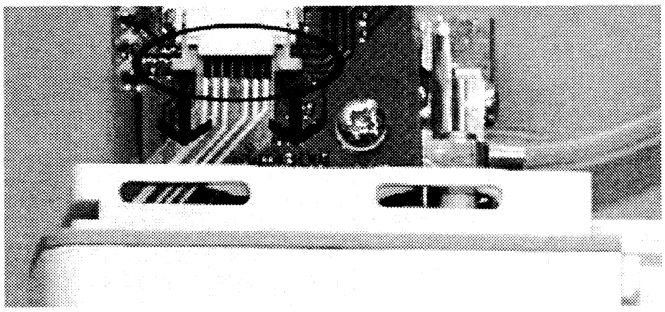


16. Disconnect the hoses from the manifold. The hoses follow the pump.

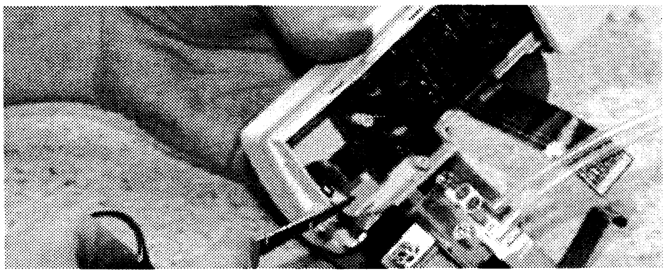
To remove the manifold unit



17. Disconnect the two (T6) screws holding the manifold to the front cover unit.

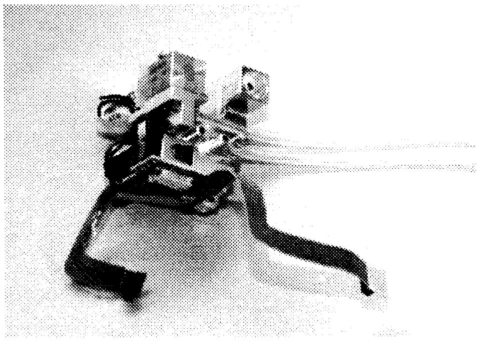


18. Open the connector lock from the NIBP flex board and disconnect the membrane keyboard flex.

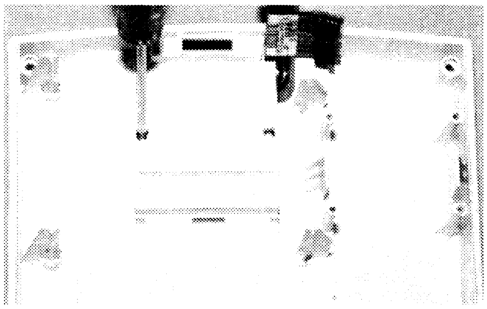


19. Lift the manifold carefully aside. Be careful not to damage the NIBP flex board. Disconnect the NIBP flex board connector from the STP input board.

NOTE: When reassembling, make sure that the NIBP flex board connector is connected properly (all pins connected) to the STP input board.

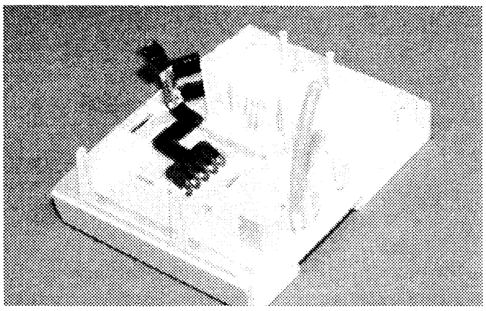


To remove the module bus connector

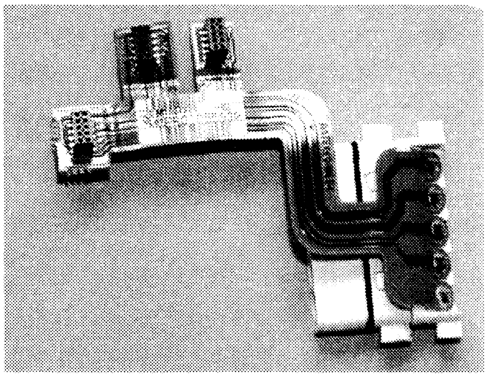


20. Use a flat blade screwdriver to unlock the module bus connector insulator cover.

    Put the screwdriver in the hole and move the blade backwards (away from the flex cable) until the insulator cover unlocks.



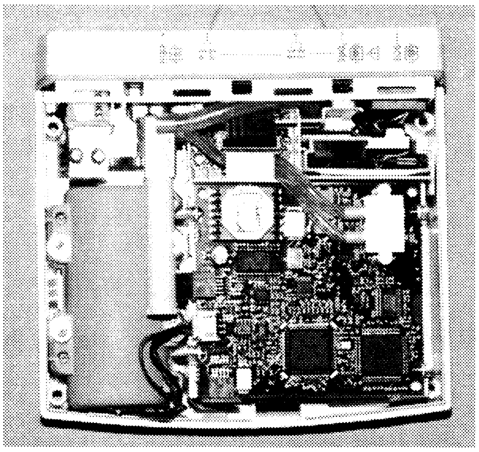
21. Pull the module bus connector carefully through the hole in the frame.



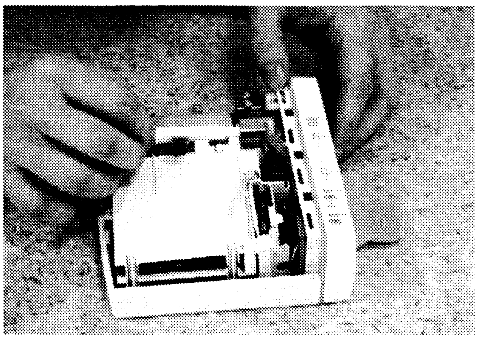
Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.3.4 To replace the NIBP filter



1. Follow the disassemble instruction steps 1, 2 and 3.



2. Remove the NIBP filter cover and replace the filter.

Reassemble the module in reverse order.

Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 NIBP calibrations

The electronics of the NIBP pressure measurement is calibrated at the factory. The processor automatically maintains the zeroing pressure. If the zero point of the pressure transducer drifts more than specified, an error message is given and the NIBP board should be recalibrated or replaced.

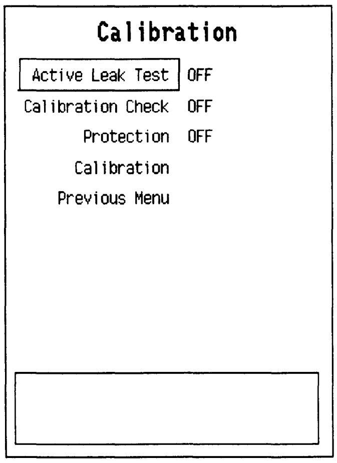
Recalibrate the NIBP measurement once a year. The checking and recalibration can be done in the NIBP service menu.

The calibration of the primary pressure channel can also be checked from the NIBP setup menu (***NIBP - NIBP Setup - Calibration Check***). In this case, the auto zeroing is performed at start - remove the hose before entering to ensure atmospheric pressure to the pressure transducers - the primary pressure is displayed. The zero-offset value should then be zero.

Check the intake air filter as part of the calibration check. Change the filter if it is visibly dirty.

Calibration check

1. Enter ***Calibration*** menu.



Calibration

Active Leak Test OFF
Calibration Check OFF
Protection OFF
Calibration
Previous Menu

2. Select ***Calibration Check*** and push the ComWheel.
3. Connect an external precision manometer to the module.
4. Pump the following pressures to manometer and check the difference between the manometer and monitor pressure display (The zeroing offset is automatically subtracted from the pressure readings).

Table 3 NIBP calibration check pressures

Pressure	Max. error	Example
0 mmHg	±5 mmHg (=zero offset)	-1
100 mmHg	100 ±2 mmHg	100 ±2
200 mmHg	200 ±3 mmHg	200 ±3

If the error of pressure channel B1 is larger than specified above, the module should be recalibrated. The error of B2 is allowed to be even twice as large because it has no effect on blood pressure measurement accuracy. However, we recommend recalibrating the module when the error of B2 is larger than specified above to ensure best possible operation.

Calibration

1. Enter ***Calibration*** menu.
2. Remove the hoses from the front panel connector to enable proper zeroing.
3. Select ***Calibration***. If it is not available, perform the steps a, b, and c.

NOTE: Do not pull out the NIBP module from the monitor frame. The module must be in the frame during the whole procedure.

a. Press the NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds to enable the calibration. This enables menu selection ***Protection***. The message 'Calibration switch ON!' appears.

b. Select ***Protection OFF*** in the Calibration menu and press the ComWheel.

c. Press the buttons again for 3 seconds. Menu selection ***Calibration*** is now enabled, and ***Protection*** is disabled. When the calibration is enabled, a message 'Calibration not protected' appears.

- Start Calibration by pressing the ComWheel. Messages 'Zeroing' and 'Zeroed' will appear in the NIBP message field. After this a pressure bar and text 'Calibrating' will appear.
- Connect an external mercury manometer with a pump to the module through the both tubes of the hose - both transducers B1 and B2 must be calibrated simultaneously. Pump up to a pressure of about 200 mmHg according to the manometer. Calibration is possible in the range of 150 to 250 mmHg.
- Verify that both pressure values in the prompt field match the manometer reading. If not, adjust by turning the ComWheel. When the values of the pressure bar and the manometer are equal, press the ComWheel to confirm the calibration. The message 'Calibrated' will appear on the NIBP digit field after a few seconds, which means that the calibration succeeded, and the new calibration data is saved in EEPROM.

NOTE: When calibrating NIBP, always change the displayed pressure value slightly with the ComWheel, even in cases where the value would be correct. For example, change the value one step higher and then back one step lower. 'Calibrated' text should appear in the display. This ensures that the calibration procedure is correctly registered and stored by the module.

- To set the protection on:
  Press NIBP module buttons **Auto ON/OFF** and **Start Cancel** simultaneously for 3 seconds. Select ***Protection ON*** and push the ComWheel. Then press the buttons again for three seconds.
- Remove the module from the frame and plug it back again. Then perform Calibration check (see the preceding page) to verify the new calibration.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate, accurate test plugs (25 °C and 45 °C) are needed. A test set of two plugs is available from Datex-Ohmeda, order code 884515.

Calibrate the temperature, when the measured test values differ for more than ±0.1 °C, and always after STP board replacement.

1. Enter ESTPR: STP service menu.
2. Enter ***Calibrations*** menu.
3. Choose ***Protection OFF*** in protect mode.
4. Select ***Calibrate T1/Calibrate T2***.
5. Insert calibration plug (25 °C) into T1/T2 connector.
6. Push the ComWheel.
7. Insert calibration plug (45 °C) into T1/T2 connector.
8. Push the ComWheel.
9. Choose ***Protection ON*** in protect mode.

3.4.3 Invasive pressure calibration

Calibrate the invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer, and when the STP board is replaced.

1. Enter ESTPR: the STP service menu.
   (**Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8) - ***Parameters***).
2. Enter ***Calibrations*** menu.
3. Connect a pressure transducer with a pressure manometer to the P1/P2 connector. Choose ***Calibrate P1*** or ***Calibrate P2***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The message 'Calibrated' will appear on the display.

4 Troubleshooting

4.1 Troubleshooting charts

See also the “User’s Reference Manual” for more troubleshooting procedures.

4.1.1 NIBP

Problem	**Cause**	**What to do**
No NIBP value displayed	NIBP not selected on screen.	Check monitor setup.
NIBP menu fading	No E-PSM(P) module, module not properly connected.	Plug in the module.
‘Artifacts’ message	Unsuccessful measurement due to patient movement, shivering, external artifact or weak signal.	
‘Weak pulsation’ message	Weak or unstable oscillation pulses due to: • artifacts • weak pulse pressure due to arrhythmias • improper cuff position or attachment • too few pulses detected • weak or unusual blood circulation • obese subject	Check patient condition and retry. Check any leaks and retry. Use proper size of cuff. Check attachment.
Call service ‘Error X’ message	NIBP hardware error. X = error number.	See the description of the error message code in NIBP error code explanation, the causes and the solutions listed in the next chapter.
Cuff loose-message	1. Hose and/or cuff not connected.	1. Connect the hose and the cuff.
	2. Hose and cuff connected. Reasons:	
	- cuff loosely wrapped	- tighten the cuff
	- leakage in cuff or hose	- replace cuff/hose
	- leakage inside module	- check internal tubing and fix if necessary
	- pump does not work	- Check pump connector; if OK, replace the NIBP Pump Unit.

Problem	**Cause**	**What to do**
Cuff ID not working	1. Defective cuff ID holes in the NIBP cuff hose	- Replace NIBP cuff hose.
	2. NIBP flex board connector wrongly connected	- Check that the NIBP flex board connector is properly connected to the STP input board: all pins have to be connected.
	3. Cuff ID switches defective	- To check the switches, attach a NIBP cuff hose without the cuff ID and check that the message 'Select inflation limit' appears. If not, replace the Front Panel Unit.
'Air leakage' message	1. Hose or cuff leaking. Reasons:	1. Replace cuff
	- cuff damaged	- replace cuff
	- cuff connector damaged	- replace cuff connector (if the fault is in hose connector)
	- O-ring damaged or missing	- replace O-ring
	- hose double connector damaged	- replace NIBP cuff hose
	2. Hose and cuff OK. Reasons:	2. Connect or replace tube
	- leakage inside the module	- replace the whole tubing
	- tube disconnected or damaged	- fix connections
	- air chamber leaking	-
	- tubes or valve(s) damaged	- replace tubes/valve(s)
'Unable to measure Sys' message	Systolic blood pressure probably higher than the inflation pressure or artifacts.	Automatic retrial with increased pressure.

Problem	**Cause**	**What to do**
'Cuff occlusion' message	1. Cuff and/or hose occluded. Reason:	
	- cuff tube kinked	- straighten tube
	- tube inside module kinked	- straighten tube
	- occlusion inside/outside module	- remove occlusion
	2. Cuff, hose, and tubes OK. Reason:	
	- fault in pressure transducer	- replace the NIBP board
	- fault in A/D converter	- replace the NIBP board
	- faulty calibration	- check calibration
'Calibration switch on' message	EEPROM protection has been handled by pressing module buttons **Auto ON/OFF** and **Start/Cancel** simultaneously for 3 seconds.	Enables setting the protection OFF in the Calibration menu. Press the buttons again if you are not going to calibrate.
Calibration not protected - message.	Calibration protection is set to OFF.	Set the protection ON in the NIBP Calibration menu.

4.1.2 NIBP error code explanation

Code	**Problem**	**What to do**
0	RAM failure; memory failure	Change the NIBP board.
1	ROM checksum error; memory failure	Change the NIBP board.
2	Pump current failure	Check short circuits. Change the NIBP board.
3	Safety CPU internal test failure or pressure sensor reference voltage failure	Change the NIBP board.
4	EEPROM protection error	Press module buttons **Auto ON/OFF** and **Start/ Cancel** simultaneously for 3 seconds.
5	Calibration not protected	Protect calibration by selecting Protection ON in the NIBP calibration menu.
6	Pressure sensors give different readings	Try to remeasure. If the problem persists, recalibrate. If the problem still persists, change the NIPB board.
7	Calibration failure	Reset the module and recalibrate. If this does not help, change the NIBP board.
8	Exhaust Valve occlusion	Check and clean the tubing and air chamber. If this does not help, change the NIBP board.
9	Measurement related error	Automatic recovery.
10	EEPROM checksum error; memory failure	Change the NIBP board.
11	Auto zero range exceeded	Calibrate the NIBP.
12	Communication break; temporal break down of communication from monitor detected	Automatic recovery.
13	Illegal neonate cuff with identifying magnet connected	Remove the cuff.
14	-	
15	Safety CPU pressure calibration error	Recalibrate. If this does not help, change the NIBP board.
16	Communication error between CPUs	Change the NIBP board.
17	Safety CPU has cut down power from pneumatics due to repeating safety limit violations	Reset the module. If the problem persists, change the NIBP board.

4.1.3 ECG

Problem	**Cause**	**What to do**
HR numerical display shows '---'	No heart rate available.	If no ECG waveform, check 'LEADS OFF' message and connect the leads.
		If ECG waveform exists, check the heart rate source e.g. in the ECG Setup menu behind ECG key.
Unacceptable ECG waveform	Poor electrode or poor electrode skin contact.	Electrodes from different manufacturers are used. /Too much/little gel is used.
	Poor electrode condition.	Electrodes are dried out.
	Improper site of electrodes.	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation.	Remove body hair. Clean the attachment site carefully with alcohol.
	Improper bandwidth filter.	Check the filter.
	Faulty/ dirty ECG cable.	Change a new cable.
No ECG trace	Waveform not selected on screen.	Press the **Monitor Setup** key and make adjustments.
	Module not plugged in correctly.	Plug in.
Noise-message	High frequency or 50/60 Hz noise.	Isolate noise source.

4.1.4 Impedance respiration

Problem	**Cause**	**What to do**
No resp trace	Waveform not selected on the screen	Press the **Monitor Setup** key and make adjustments.
	Module not plugged in correctly	Re-plug the module.

Problem	**Cause**	**What to do**
Unacceptable resp waveform	Poor electrode or poor electrode skin contact	Electrodes from different manufacturers are used. Too much/little gel is used.
	Poor electrode condition	Electrodes are dried out.
	Improper site of electrodes	Check that electrodes are not placed over bones, active muscles, or layers of fat.
	Improper skin preparation	Remove body hair. Clean the attachment site carefully with alcohol.
	Faulty/ dirty ECG cable.	Change a new cable.
Message: 'SMALL RESP CURVE'	Respiration signal is very small	With 3-lead cable, try another lead connection I, II, III or try 5-lead cable.
Message: 'APNEA ALARM', and respiration waveform normal	Respiration source is CO_2	Check the respiration source and change it to the correct one.

4.1.5 Pulse oximetry (SpO_2)

Problem	**Cause**	**What to do**
Message 'NO PROBE'	No probe connected to the monitor.	Check probe connections.
	Probe faulty.	Change the probe.
Message 'PROBE OFF' though probe properly attached to the patient	Unsuitable site.	Try another site.
	Probe faulty.	Try another probe.
	Probe connection cable not connected to probe.	Connect the cable to probe.
Finger probe falls off	1. Probe is slippery.	1. Wipe with 70% isopropyl alcohol and allow drying.
	2. Finger is too thin or thick.	2. Try other fingers, or other probe types.
Weak signal artifacts	Poor perfusion.	Try another place.
	Movement artifacts.	
	Shivering.	
Message 'NO PULSE'	Pulse search > 20 sec. and low SpO_2 or low pulse rate.	Try other fingers.
Message 'ARTIFACT'	Pulse modulation exceeds the present scale.	Try another place or another probe.
Message 'CHECK PROBE'	DC value not in balance.	Try another probe.
Message 'POOR SIGNAL'	Poor perfusion. Modulation (Red or Ired) < 0.25%	Check that the sensor is positioned correctly to the patient.
Message 'FAULTY PROBE'	Probe is faulty.	Change the probe.
No SpO_2	No waveform selected on screen.	Check the selected SpO_2 waveforms by pressing **Monitor Setup** key and selecting ***Modify waveforms***.
	Wrong configuration setting.	Check the configuration settings from the STP/Calibrations menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***)

4.1.6 Temperature

Problem	**Cause**	**What to do**
Message 'TEMPERATURE ERROR'	Faulty calibration.	Perform calibration. If it does not help, check that the front panel connector is properly connected to the STP board.

Problem	Cause	What to do
No temperature displayed	Wrong type of probe.	Use correct probe.
	Temperature out of measurable range.	The range is between 10 and 45 °C.
	Temperature calibration not protected.	Set the protection ON in the Service Menu.

4.1.7 Invasive blood pressure

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check the selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms.
		Check that the pressure transducer is open to the patient.
	Wrong configuration setting	Check the configuration setting from the STP/Calibrations menu (**Monitor Setup** ***- Install/Service - Service - Parameters***)
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P1 /P2 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel.
		Offset is > 150 mmHg. Open the transducer to air and zero the channel.
		Defective transducer. Replace it and zero the channel.
'Calibration failed' message	Unsuccessful calibration of P1/P2 (number field), possibly due to a pulsating waveform	Turn the transducer to sphygmomanometer and try again (zeroing takes place first).
		Gain is beyond the limits (± 20% of the default gain). Replace the transducer.
Out of range < 40 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel.

Problem	Cause	What to do
Out of range > 320 mmHg	Measurement pressure is beyond the measurement range.	Check the transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check the transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowcharts

4.2.1 Module troubleshooting for NIBP parameter

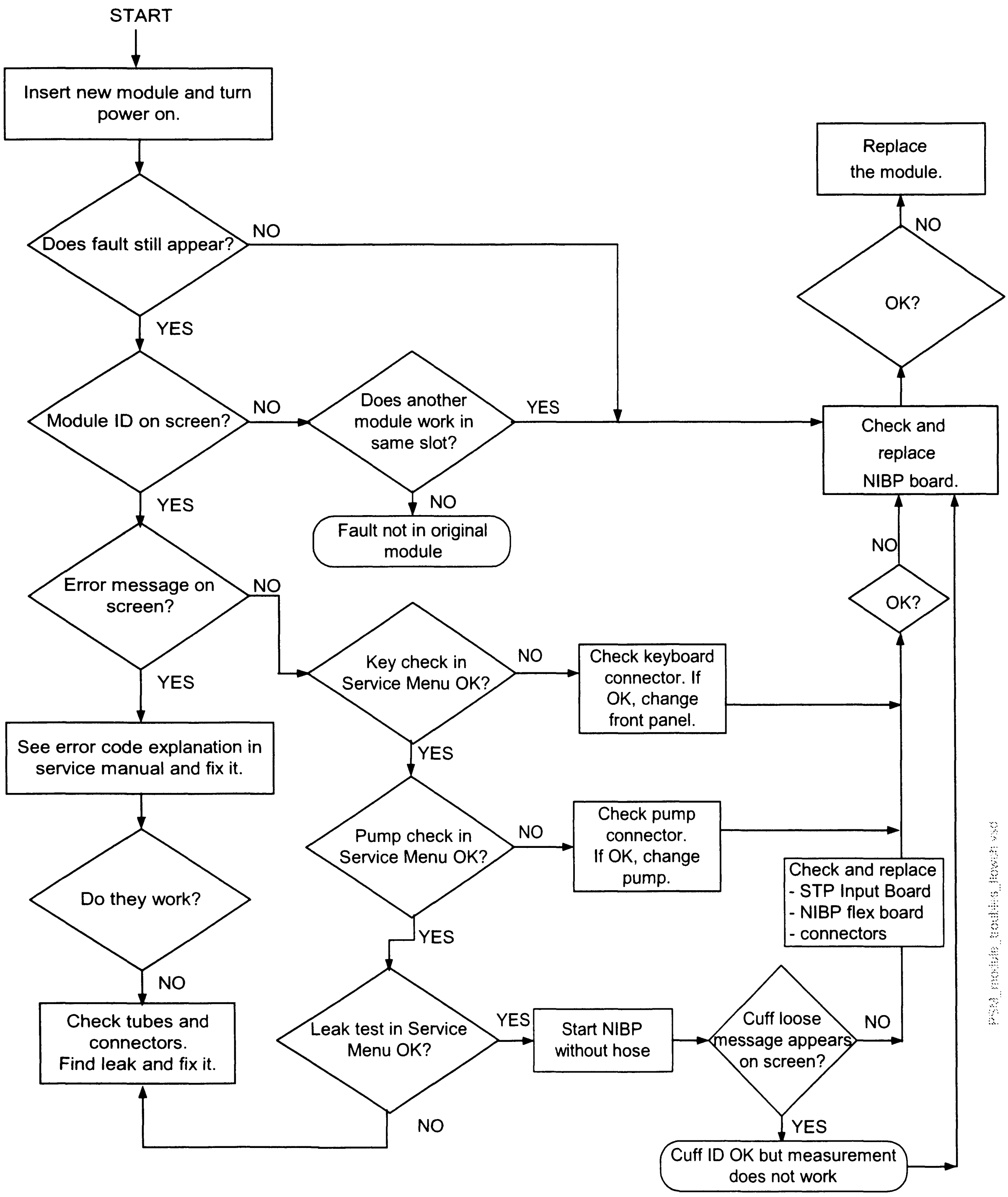

START
Insert new module and turn power on.
Does fault still appear?
NO
YES
Module ID on screen?
NO
Does another module work in same slot?
YES
NO
Fault not in original module
YES
Error message on screen?
NO
YES
See error code explanation in service manual and fix it.
Do they work?
NO
Check tubes and connectors. Find leak and fix it.
Key check in Service Menu OK?
NO
Check keyboard connector. If OK, change front panel.
YES
Pump check in Service Menu OK?
NO
Check pump connector. If OK, change pump.
YES
Leak test in Service Menu OK?
YES
NO
Start NIBP without hose
Cuff loose message appears on screen?
NO
YES
Cuff ID OK but measurement does not work
Check and replace
- STP Input Board
- NIBP flex board
- connectors
OK?
NO
Check and replace NIBP board.
OK?
NO
Replace the module.
PSM_module_troublts_flowch.vsd

Figure 13 Troubleshooting flowchart for NIBP Parameter

4.2.2 Module troubleshooting for parameters ESTPR

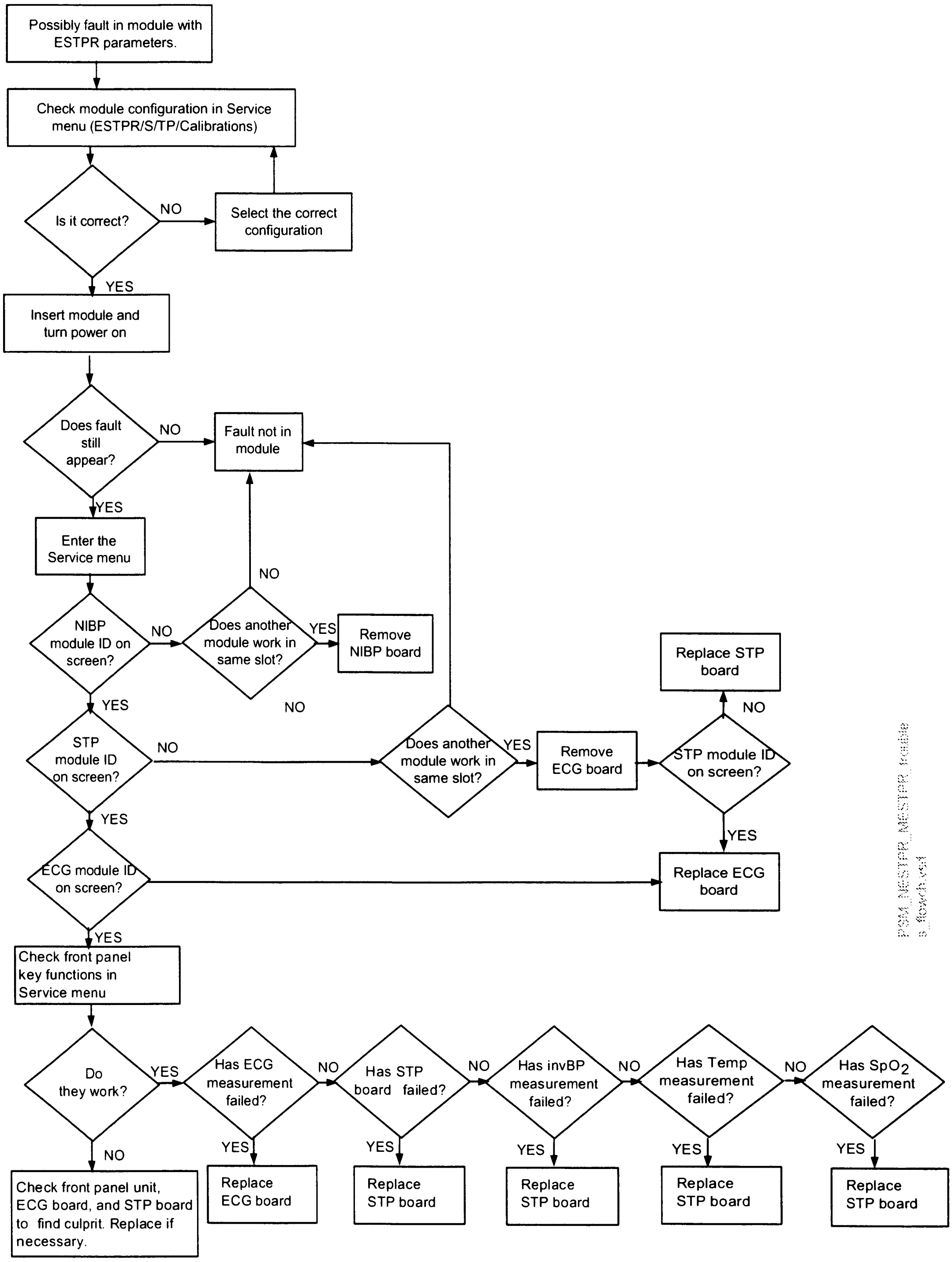

Possibly fault in module with ESTPR parameters.
Check module configuration in Service menu (ESTPR/S/TP/Calibrations)
Is it correct?
NO
Select the correct configuration
YES
Insert module and turn power on
Does fault still appear?
NO
Fault not in module
YES
Enter the Service menu
NO
NIBP module ID on screen?
NO
Does another module work in same slot?
YES
Remove NIBP board
NO
YES
STP module ID on screen?
NO
Does another module work in same slot?
YES
Remove ECG board
STP module ID on screen?
NO
Replace STP board
YES
Replace ECG board
YES
ECG module ID on screen?
YES
Check front panel key functions in Service menu
Do they work?
YES
Has ECG measurement failed?
NO
Has STP board failed?
NO
Has invBP measurement failed?
NO
Has Temp measurement failed?
NO
Has SpO2 measurement failed?
YES
Replace ECG board
YES
Replace STP board
YES
Replace STP board
YES
Replace STP board
YES
Replace STP board
NO
Check front panel unit, ECG board, and STP board to find culprit. Replace if necessary.
PSM_NESTPR_MESTPR_trouble s_flowch.vsd

Figure 14 Troubleshooting flowchart for ESTPR Parameters

APPENDIX A Service check form, Patient Side Module, E-PSM, E-PSMP

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

All modules	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. NIBP pump filter	☐	☐	☐	4. Module installation	☐	☐	☐
5. Module recognition	☐	☐	☐				
Notes							

ECG measurement	S/N
6. Module software (serial numbers)	
ECG/RESP	
STP	
NIBP	

	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
7. Communication and memories	☐	☐	☐	8. Power frequency	☐	☐	☐
9. Cable recognition	☐	☐	☐	10. Lead detection	☐	☐	☐
11. Test with the patient simulator	☐	☐	☐				
Notes							

RESP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
12. RESP measurement recognition	☐	☐	☐	13. Test with patient simulator	☐	☐	☐
Notes							
TEMP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
14. Communication and memories	☐	☐	☐	15. Temperature probe detection	☐	☐	☐
16. Calibration check	☐	☐	☐	17. Temp test	☐	☐	☐
18. Module configuration	☐	☐	☐				
Notes							
InvBP measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
19. Membrane keys	☐	☐	☐	20. Cable and transducer detection	☐	☐	☐
21. Calibration	☐	☐	☐	22. Test with patient simulator	☐	☐	☐
Notes							
Sp02 measurement					S/N		
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
23. Sp02 probe detection	☐	☐	☐	24. Test measurement	☐	☐	☐
Notes							

NIBP measurement				S/N			
	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
25. Communication and memories	☐	☐	☐	26. Membrane keys	☐	☐	☐
27. Pump and valves	☐	☐	☐				
28. Leak test							

29. Calibration check	Measured B1	Measured B2	Allowed range
0 mmHg			±9 mmHg
100 mmHg			100 ±2 mmHg
200 mmHg			200 ±3 mmHg
260 mmHg			260 ±4 mmHg
30. Safety valve functions	Measured B1	Measured B2	Allowed range
			270...330 mmHg
			270...330 mmHg
			130...165 mmHg
			130...165 mmHg

	OK	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
31. Cuff related messages	☐	☐	☐	32. Test measurement	☐	☐	☐
33. NIBP hose detection	☐	☐	☐				
Notes							

All modules							
	OK	N.A.	Fail		OK	N.A.	Fail
34. Electrical safety check	☐	☐	☐	35. Functioning after electrical safety check	☐	☐	☐
36. Final cleaning	☐	☐	☐				
Notes							

Notes

Used spare parts			

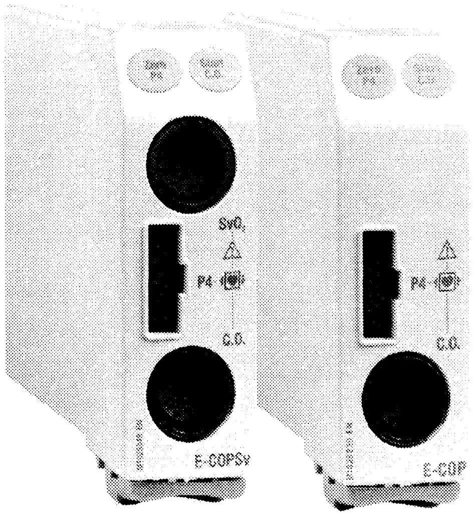
Signature

Datex-Ohmeda

Cardiac Output Modules

S/5™ Cardiac Output and SvO_2 Module, E-COPSv (Rev. 00)
S/5™ Cardiac Output Module, E-COP (Rev. 00)

Technical Reference Manual



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027825
June, 2005

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Cardiac Output Modules, E-COP and E-COPSv (Rev. 00) A-1**

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of Cardiac Output Modules, E-COP and E-COPSv. Cardiac Output Modules, E-COP and E-COPSv, are single width plug-in modules designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

Both modules E-COP and E-COPSv provide

- Cardiac output (C.O.)
- Right ventricular ejection fraction (REF)
- Invasive blood pressure (InvBP) measurement

Additionally, the COPSv module provides venous oxygen saturation (SvO_2) measurement.

NOTE: Do not use identical modules in the same monitor simultaneously. The modules E-COP/M-COP and E-COPSv/M-COPSv are considered as identical and would cause communication errors if used in the same system.

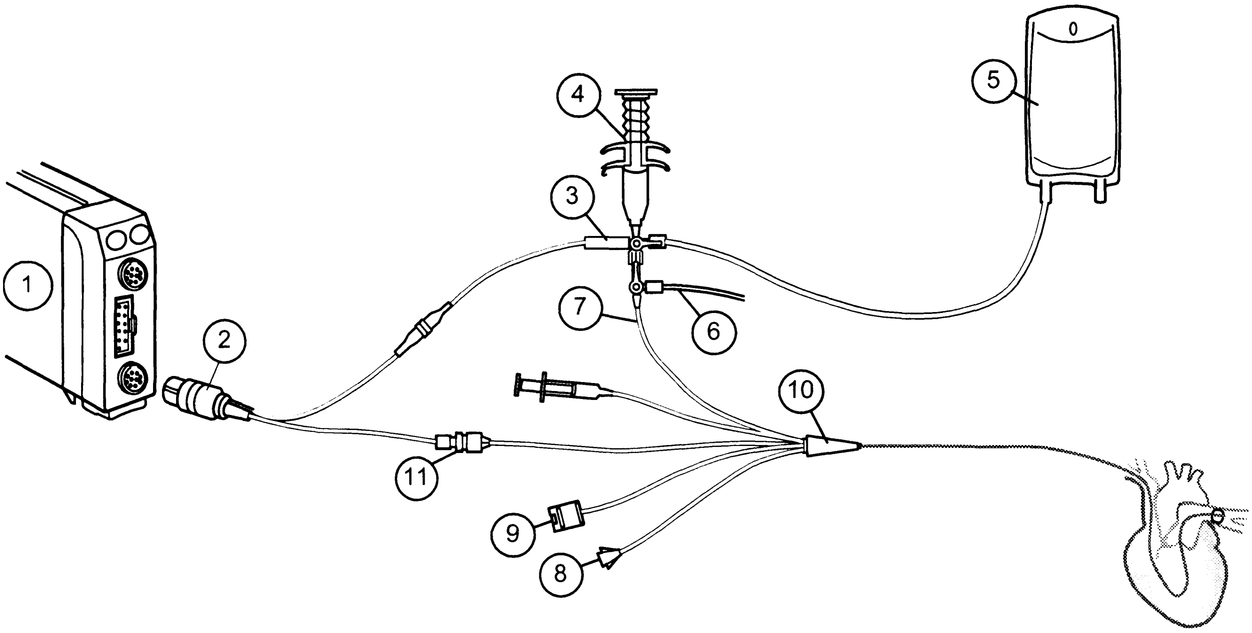


Figure 1 Cardiac output setup with closed injectate delivery system

(1) Module with C.O. measurement capability

(2) Catheter connecting cable

(3) Injectate temperature probe

(4) Injectate syringe

(5) Injectate: 5% dextrose or physiological saline at 0 to 27 °C (32 to 77 °F)

(6) CVP line to InvBP transducer

(7) Proximal

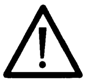
(8) Distal

(9) Optical connector

(10) Thermodilution catheter (Edwards Lifesciences corp. compatible)

(11) Catheter's termistor

Equipment safety symbols



When displayed on the E-COP and E-COPSv modules, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

Module size (W × D × H)	37 x 187 x 112 mm / 1.5 x 7.4 x 4.4 in
Module weight	0.35 kg / 0.8 lb.
Power consumption, E-COP	Approximately 3.5 W
Power consumption, E-COPSv	Approximately 5 W

1.2 Typical performance

1.2.1 C.O.

Measurement range	0.1...20 l/min
Display resolution	0.01 l/min
Repeatability	±2% or ±0.02 l/min
Injectate temp range (with Edward Lifesciences Corp. tempearture probes) and accuracy	0...25.5 °C ±0.3 °C (32...77.9 °F ±0.5 °F) 25.5...27.0 °C ±0.5 °C (77.9...80.6 °F ±0.9 °F)
Blood temp range (with Edward Lifesciences Corp. catheters) and accuracy	17.5...31 °C ±0.5°C (63.5...87.8 °F ±0.9 °F) 31.0...43.0 °C ±0.3°C (87.8...109.4 °F ±0.5 °F)
Protection against electric shock	type CF defibrillation proof

1.2.2 REF

Repeatability	±2% as measured by electronically generated pulsatile curves for range 10 % - 60 %. For other ranges accuracy is unspecified.

1.2.3 SvO_2

Measurement range	1% to 98%
Measurement accuracy	±2% SvO_2 equals 1 standard deviation for range of 30% to 95% SvO_2 and 6.7 to 16.7 g/dl Hb when using in vivo calibration.
Display resolution	1%
Catheters	Edward Lifesciences Corp. SvO_2 catheter and optical module (OM-2E)

1.2.4 InvBP

Measurement range	-40...+320 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±20%
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.

Sweep speed	12.5, 25, 50 mm/s
Numerical display	
Range	-40...+320 mmHg
Resolution	1 mmHg
Waveform display	
Range	-30...+300 mmHg
Pulse rate	
Measurement range	30...250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm
Respiration artifact rejection	

1.3 Technical specifications

The numerical display is averaged over 5 seconds and updated at 5 second intervals.

Measurement accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 µV/V/mmHg
Input voltage	5 VDC
Max current	20 mA
Nonlinearity	<1%, 0 to 200 mmHg
	<2%, -40 to 0 and 200 to 320 mmHg
Frequency response, waveform filter	DC...Upper limit
adjustable upper limit	4...22 Hz (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	< 15 sec.
Protection against electric shock	type CF defibrillation proof

NOTE: The accuracy of the measurement may be different from the specified accuracy, depending on the transducer/probe used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

2.1.1 Cardiac output and REF

Cardiac output measurement is performed using the principle of thermodilution. During measurement, the catheter lies in the heart, with an injection port in the right atrium (RA) and a thermistor, which is to monitor blood temperature, in the pulmonary artery (PA). A small, known amount of thermal indicator is injected into the RA and is mixed with the blood on its way to the PA. The catheter thermistor measures the decrease in blood temperature as the blood flows past the thermistor in the PA.

The information is stored in the module and the cardiac output is calculated from the area beneath the time-temperature Cardiac Output Measurement Curve, as shown in figure 2.

The area under the time-temperature curve is inversely proportional to the flow rate which corresponds to cardiac output.

The cardiac output is calculated from the equation:

$C.O. = (1.08\, C_T\, 60\, V_i(T_B - T_i))/(T_B dt + C)$

where:

$C.O.$ = cardiac output in liters/minute

1.08 = factor comparing the density and specific heat of 5% dextrose solution in water to those of blood.

C_T = correction factor for the injectate temperature rise as it passes through the catheter and its dead space

60 = seconds/minute

V_i = injectate volume in liters

T_B = baseline blood temperature (°C)

Ti = injectate temperature

$T_B dt$ = area under time-temperature curve between time o and x, where x is the time when the curve has dropped to 30% of its peak value.

C = area beneath time-temperature curve between x and the end of the curve.

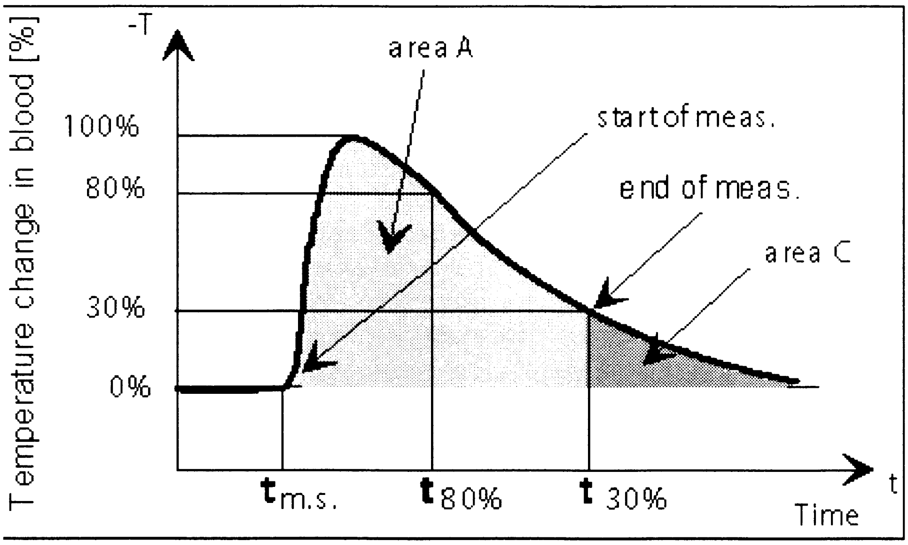


Figure 2 Cardiac output measurement curve

A = area derived by integration of the time-temperature curve

C = area beneath the time-temperature curve between t_{30}% and end of the curve. Computation based on an exponential fit to the curve between t_{80}% of the peak and t_{30}%.

REF (right ventricular ejection fraction) measurement is a part of the time-temperature (thermodilution) cardiac output measurement. Ejection fraction is determined using an exponential technique by synchronizing sensed R-waves with points of temperature changes on the time-temperature curve. Once ejection fraction, cardiac output, and heart rate are known, right ventricular volumes may be calculated. The measurement requires a Baxter-Edwards fast response thermistor catheter and an ECG module to synchronize R-wave detection to the time-temperature curves.

2.1.2 SvO_2 measurement

The COPSv module measures SvO_2 when coupled with a Baxter-Edwards OM-2E optical module and a Swan-Ganz oximetry catheter. To measure SvO_2, the system utilizes a spectrophotometric technique involving the use of light emitting diodes (LEDs) that produce red (660 nm) and infrared (810 nm) light. The light is transmitted to the blood through a single plastic optical fiber in the oximetry catheter and reflected back through a separate optical fiber to a photodetector in the optical module. The light is electrically transmitted to the COPSv module and analyzed to determine SvO_2.

The oximetry portion of the system measures SvO_2 in the pulmonary artery by detecting color changes in the red blood cells. When pulses of red and infrared light are transmitted through the oximetry catheter, the light is reflected from the red blood cells and transmitted back through the catheter to the optical module. The amount of light reflected at each wavelength depends primarily on the color of the blood and the number of red blood cells. Since the number of red blood cells in the blood affects the amount of reflected light, the differences are compensated for when the patient's total hemoglobin value is entered. The optical module stores and transfers SvO_2 calibration data. SvO_2 values can be affected by the presence of methemeglobin or carboxyhemoglobin which imitate the absorption characteristics of HbO_2. Large concentrations of methemoglobin or carboxyhemoglobin could then cause a falsely elevated SvO_2. In cases where dysfunctional hemoglobins are suspected, SvO_2 should be interpreted with caution.

2.1.3 Invasive blood pressure measurement

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The pressure transducer is placed at the same level with the heart, and electrically zeroed.

The pressure transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that blood pressure data and blood pressure waveforms can be displayed.

2.2 Main components

The Cardiac Output Module, E-COP, consists of a COP circuit board and two input boards - a CO input board and a P input board, attached to the front panel.

The Cardiac Output and SvO_2 Module, E-COPSv, consist of a COPSv circuit board and three input boards - a CO input board, a SvO_2 input board, and a P input board, attached to the front panel.

The front panels are shown in figure 3.

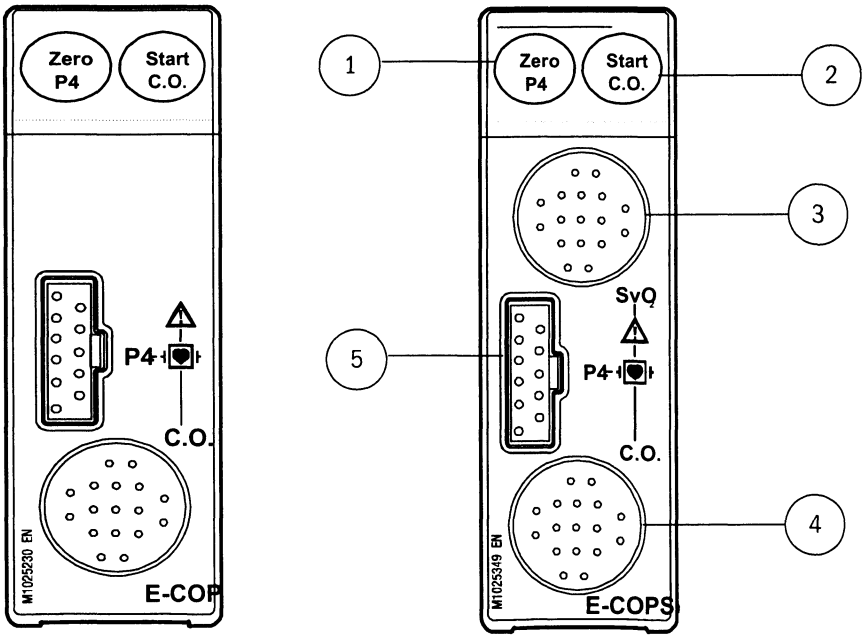


Figure 3 Front panels of Cardiac Output Modules, E-COP and E-COPSv

(1) Key for pressure zeroing (**Zero P4**)

(2) Key for cardiac output measurement (**Start C.O.**)

(3) Connector for SvO_2 measurement

(4) Connector for C.O. measurement

(5) Connector for invasive blood pressure measurement

2.2.1 COP board

The COP board consists of the following functional sections.

- Processor

- Cardiac output measurement
- Invasive blood pressure measurement
- Serial communication
- Isolation
- Power supply

Processor section

The microprocessor uses the Intel 80C196KC-16 CPU which includes three A/D converters and a UART. The microprocessor uses external memories, an 8-bit data bus, a 16 MHz oscillator, and a watchdog timer. The three A/D-converters within the CPU convert the analog input signals to digital. The internal UART communicates and transfers data between the module and the CPU board in the monitor.

Cardiac output measurement section

The catheter and the probe contain an NTC resistor that reacts to temperature change.

The temperature dependent voltage across the NTC resistor is amplified and an offset value is added to it. The resultant signal is then regulated into a ±5 V range by voltage slicing and sent to an A/D converter.

Because the temperature measurements are calibrated digitally and non-linearity of catheter/probe is compensated for by software, ambient temperature change after calibration is the only factor that may influence the measurement.

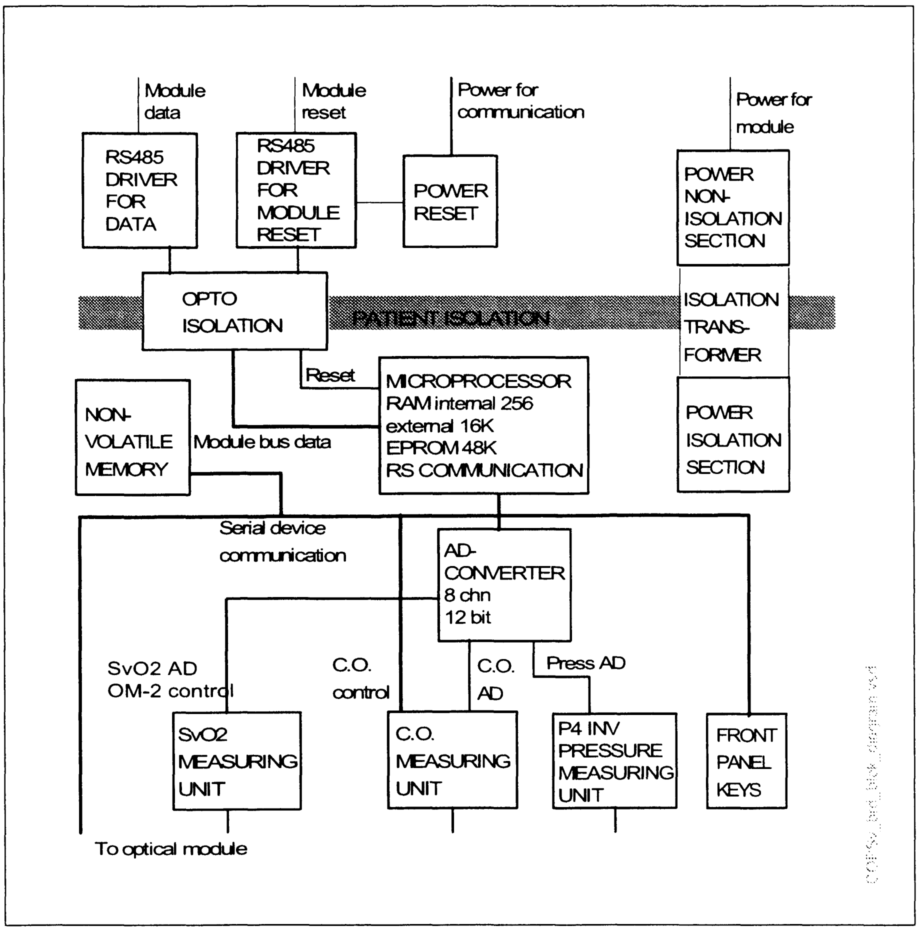

Module data
Module reset
Power for communication
Power for module
RS485 DRIVER FOR DATA
RS485 DRIVER FOR MODULE RESET
POWER RESET
POWER NON-ISOLATION SECTION
OPTO ISOLATION
PATIENT ISOLATION
ISOLATION TRANS-FORMER
Reset
MICROPROCESSOR RAM internal 256 external 16K EPROM 48K RS COMMUNICATION
NON-VOLATILE MEMORY
Module bus data
POWER ISOLATION SECTION
Serial device communication
AD-CONVERTER 8 chn 12 bit
SvO2 AD OM-2 control
C.O. control
C.O. AD
Press AD
SvO2 MEASURING UNIT
C.O. MEASURING UNIT
P4 INV PRESSURE MEASURING UNIT
FRONT PANEL KEYS
To optical module

Figure 4 **COPSv board block diagram, on COP board the SvO_2 section is excluded**

Invasive blood pressure measurement section

An isolated +5 V supply is connected to the input of the pressure transducer bridge circuit. A differential voltage, which depends on blood pressure and input supply voltage, is calculated from the bridge circuit output using the following formula:

Uout = Uin x Pressure x 5 V, where Uin = 5 V ⇒ Uout = 25 V x Pressure [mmHg]

Pressure amplification is performed by the instrumentation amplifier. The gain of the amplifier is set so that the level of the signal transferred to the A/D converter stays within the measurement range even when there are circumstantial offsets or offsets caused by the pressure transducer. The input filter before the amplifier attenuates high frequency disturbances.

A FET switch cuts the measurement current and detects the existence of the pressure transducer. The existence of the pressure transducer is also checked digitally by a jumper next to the connector.

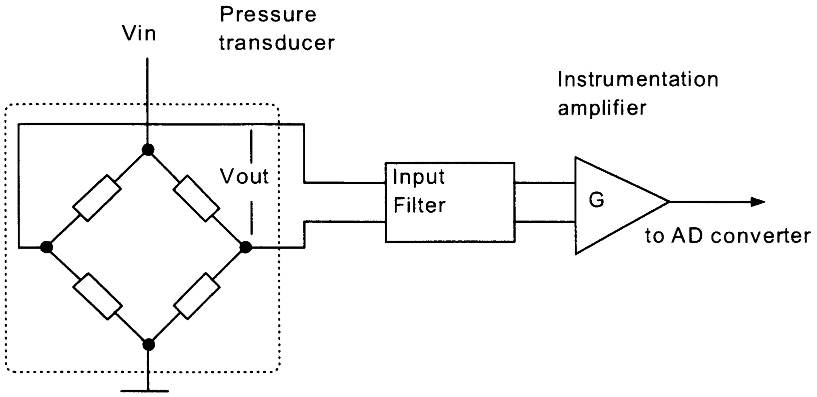


Figure 5 **Pressure transducer principle of operation**

Serial communication

Serial communication between the Cardiac Output Module and the Central Unit Frame is established via an RS485 type bus. The communication bus drivers are powered from the Module Bus. The module isolation section is powered (+5 V) from the isolated power supply.

The communication drivers are controlled by a reset signal so that when the reset is active, the drivers do not transfer data.

In addition to the RS485 reset, there is a logic power-up reset, which holds for approximately 500 ms regardless of the state of the RS485 reset. A time constant determines the power-up reset time. The power-up reset also prevents the module from sending data to the Module Bus. The data transmission rate is 500 kbps.

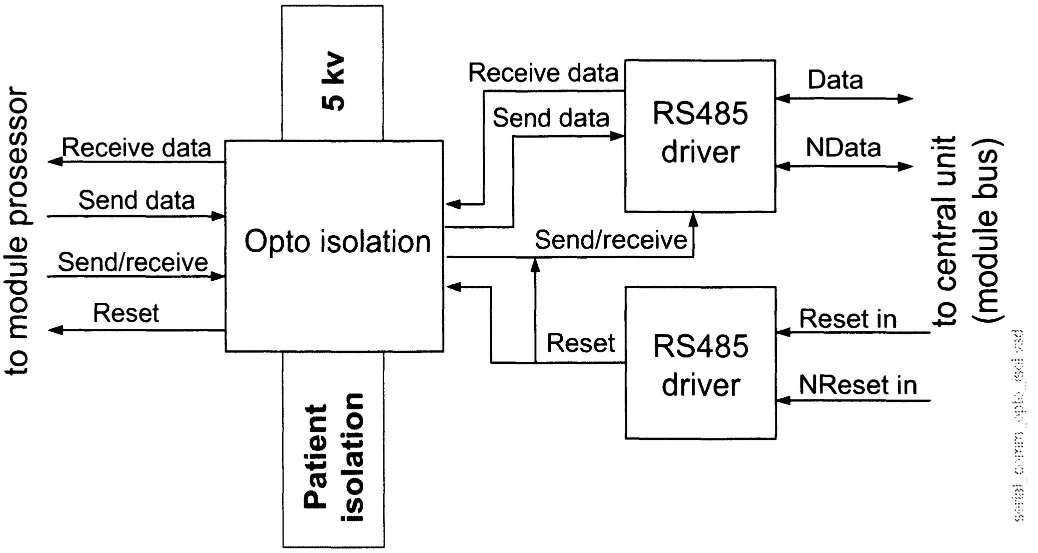

to module processor
Receive data
Send data
Send/receive
Reset
5 kv
Opto isolation
Patient isolation
Receive data
Send data
RS485 driver
Send/receive
Reset
RS485 driver
Data
NData
Reset in
NReset in
to central unit (module bus)
serial_comm_opto_isol.vsd

Figure 6 **Serial communication and opto isolation**

Isolation section

There are two opto isolators, one for data and one for the reset signal. Signals are processed on logical high-low levels even though the outputs of the opto isolators in the isolation section are analog signals.

The reset line is an open collector type with a pull-up resistor, so that the microprocessor is able to use its internal watchdog function.

Power supply section

The module isolated power supply is developed from the +15 Vdirty (non isolated) supply from the Central Unit power supply.

The isolated power supply is a switched-mode circuit, where an FET switch is controlled by an oscillator using a bipolar timer. The frequency of the oscillator is approximately 30 kHz, with a pulse ratio of 50%; switching of the FET is slow to suppress spurious interference. A special isolation pulse transformer is used in the circuit. The transformer secondary circuit uses normal linear regulators, except for +5 V which uses a low drop type linear regulator.

2.2.2 COPSv board

The COPSv board consists of the same functional sections as the COP board, except for the cardiac output self test section. Additionally, the COPSv board consists of the SvO_2 measurement section.

SvO_2 measurement section

The SvO_2 algorithm is part of the COPSv module software. The algorithm consists of five different parts; initialization, calibrations, signal processing and SvO_2 calculation, automatic gain control, and signal quality analysis.

Initialization

When the optical module is connected to the COPSv module, a number of start-up procedures are performed prior to normal operation. These procedures include transfer of calibration factors from the optical module to the COPSv module and initialization of LED currents.

Calibration

The system is calibrated according to either in-vitro or in-vivo calibration. In-vitro calibration is performed before the oximetry catheter is removed from the package with the catheter tip still inside the calibration cup. The resulting calibration factor is calculated on the basis of the measured ratio of red and infrared signals and the ideal ratio for the calibration cup. In-vivo calibration is performed when the catheter is inserted into the patient's pulmonary artery. The resulting calibration factor is based on the measured ratio of red and infrared signal and the Hgb and SvO_2 values measured in a laboratory. If the calibration is skipped, the result of an old calibration is used instead and the 'Not calibrated' message is displayed in the SvO_2 number field.

Signal processing and SvO_2 calculation

The reflected red and infrared signals transferred from the optical module to the COPSv module are filtered, and SvO_2 is calculated on the basis of the ratio of the two signals.

Automatic gain control

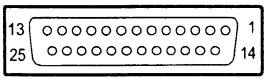
The intensity of the red and infrared signals can be amplified by four different gains. The gain is selected automatically to achieve optimal signal levels.

Signal quality

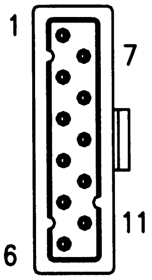
The reflected red and infrared signals are checked for wall contact artifacts, pulsatility and intensity shifts. An index is calculated to indicate the signal quality. 0 indicates a normal signal, 1 indicates an intermediate signal, 2 indicates a poor signal, and 3 indicates an unacceptable signal. Please refer to the service menu section for more information.

2.3 Connectors and signals

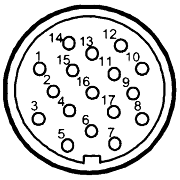
2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7		Ground & Shield
	8	I	-RESET_RS485
	13		Ground & Shield
	15	I	GroundDIRTY
	24	I	+5 VDC
	25	I	+5 VDC
	Other	NC	Not Connected

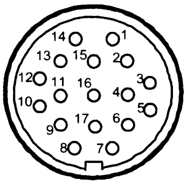
2.3.2 Invasive blood pressure connector

Invasive blood pressure connector (P4)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage
	2	BP SIG+	BP transducer signal positive (+)
	3	NC	Not connected
	4	AGND	Analog ground
	5	NC	Not connected
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-)
	9	NC	Not connected
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

2.3.3 Cardiac output connector (C.O.)

	Pin	Signal
	1	BAB
	2	THB
	3	BAC
	4	Not connected
	5	Shield
	6	Not connected
	7	THD
	8	THA
	9	THC
	10	BAA
	11	Not connected
	12	Not connected
	13	Not connected
	14	FL
	15	Not connected
	16	Not connected
	17	Not connected

2.3.4 SvO_2 connector (SvO_2)

	Pin	Signal
	1	IR_CATHODE
	2	CE
	3	SK
	4	DATA_OUT
	5	CHASSIS_GND
	6	SVO2_GND
	7	HEATER_RTN
	8	REMOTE_OUT
	9	+V_OPT
	10	TEMP_SENSOR
	11	HEATER_HI
	12	LOCAL_OUT
	13	REF_RTN
	14	LED_ANODE
	15	RED_CATHODE
	16	DATA_IN
	17	-V_OPT

3 Service procedures

3.1 General service information

The field service of the E-COP and E-COPSv modules is limited to replacing faulty mechanical parts.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Patient simulator		
SvO_2 simulator	890121	
Pressure manometer		
InvBP transducer		
Catheter connecting cable		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that

   - screws are tightened properly
   - cables are connected properly

- there are no loose objects inside the module

✍

2. External parts

   Check that

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup* - *Waveform Fields* - *Field 4* - *P4***
Digit Fields* - *Field 4* - *SvO2

Preset the C.O., SvO$_2$ and InvBP measurement settings:

Others - ***C.O.* - *C.O. Setup* - *Scale* - *1.0 °C***
Injectate Volume* - *10 ml
Measurement Mode* - *SET
SvO2* - *Update Hb* - *115 g/l
Invasive Pressures - ***P4 Setup* - *Label* - *PA***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

   ✍

4. Recognition

   Check that the module is recognized by entering the ***C.O.*** menu:

   Others - ***C.O.***

   Check that the message 'No Catheter' is shown in the middle of the menu. In the case of the E-COPSv module, also check that the message 'No cable' is shown in the digit field for SvO$_2$.

   ✍

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

Take down the information regarding COP software by selecting ***Scroll vers*** and turning the ComWheel.

✍

6. Communication and memories

   Enter the ***COP*** module service menu:

   Parameters - COP

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all show OK.

   ✍

Invasive blood pressure measurement

7. Membrane key

   Check the front panel membrane key **ZERO P4**.

   Press the key for at least one second. Check that the key being pressed is identified, i.e. the information in the Service Data field under Button - P4 changes from OFF to ON.

   ✍

8. Cable and transducer detection

   Check that Cable and Probe for P4 show OFF. Plug a cable with an invasive blood pressure transducer into the front panel connector P4 and check that Cable and Probe show ON and the corresponding pressure waveform appears on the screen.

   ✍

9. Calibration

   Calibrate InvBP channel P4 according to the instructions in section "Invasive pressure calibration".

   ✍

10. Test with patient simulator

    Return to the normal monitoring screen by pressing the **Normal Screen** key on the Command Board. Check the InvBP channel with a patient simulator.

    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    SENSITIVITY switch; 5 µV/V/mmHg
    ECG - BASE - BPM - 60
    BP - 3 - WAVE - ATM

    Connect the cable from channel BP3 to module connector P4. Zero the InvBP channel P4 by pressing the **ZERO P4** key on the module front panel.

    BP - 3 - WAVE - PA

Check that appropriate InvBP waveforms are shown and the InvBP value is approximately 25/10 (±2 mmHg) for channel P4 (PA).

✍

SvO_2 measurement

11. Measurement state

    Enter the ***COP*** module service menu. Check that the SvO_2 values Meas. state, OM fail and OM temp. all show NO OM.

    Turn the SvO_2 simulator's pulsation switch to Medium and the range switch to Normal pulse. Connect the simulator to the module and check that the following messages appear in the digit field for SvO_2:

    Initializing, please wait --> Warming up --> Not calibrated

    Check that Meas. state has changed to NORMAL and OM fail and OM temp. show OK.

NOTE: OM temp. may show UNSTABLE at first, but the message should change to OK within half a minute.

✍

12. Calibration

    Perform an In-Vitro calibration. Keep the SvO_2 simulator connected to the module and turn the pulsation switch to No pulse.

    Enter the ***SvO2*** menu:

    Others - ***SvO2***

    Select ***Calibrate in Vitro*** to start the calibration. Wait until the text Start SvO_2 appears in the menu.

    Turn the SvO_2 simulator pulsation switch to Normal Pulse and complete the calibration by pressing the ComWheel again. Wait until the text Calibrating disappears from the digit field for SvO_2.

    Check that the calibration date for In-Vitro calibration was updated correctly and the SvO_2 reading on the screen is 81% (±2).

✍

13. SvO_2 messages

    Turn the SvO_2 simulator pulsation switch to No pulse and check that the message 'Check cath. position' appears in the digit field for SvO_2 and the message 'SvO_2 poor signal' appears in the message field within one minute.

    Turn the pulsation switch to High pulse and check that the two messages remain on the screen.

Turn the pulsation switch back to Normal pulse and check that the messages disappear within one minute.

✍

Cardiac Output measurement

14. Membrane key

    Check the front panel **START C.O.** membrane key.

    Enter the ***COP*** module service menu. Press the key for at least one second and check that it is identified, i.e. the information on the service menu under Button - C.O. changes from OFF to ON.

    ✍

    Enter the ***C.O.*** menu:

    Others - ***C.O.***

    Connect a catheter connecting cable to module connector C.O.

15. Test with patient simulator

    Check the C.O. measurement with a patient simulator.

    The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

    C.O. - BASE - 37 °
    WAVE

    Leave the WAVE menu open on the simulator. Connect the catheter connecting cable (both connectors) to the simulator's C.O. box. Select the text START C.O. SET on the ***C.O.*** menu.

    Press the ComWheel to start the measurement. When the text 'Inject now!' appears on the menu, select the setting 5 l/min (F3) from the medSim 300 simulator. Check that the thermodilution curve displayed returns to the base level on the screen. Complete all 6 measurements.

NOTE: The medSim 300 simulator may give an inaccurate C.O. signal immediately after it has been turned on and after each new simulator setting. This property of the simulator must be taken into account when interpreting the C.O. results.

When the set is complete, exclude the first measurement from the average using the ***C.O.*** menu functions:

Edit Average - Exclude Curves - 1

Press the ComWheel to exclude the first curve. Check that each of the remaining results is within ±2% of the new average.

✍

All modules

16. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

17. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

18. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

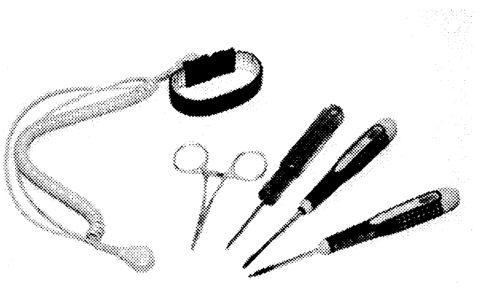
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the Cardiac Output Modules, E-COP and E-COPSv (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

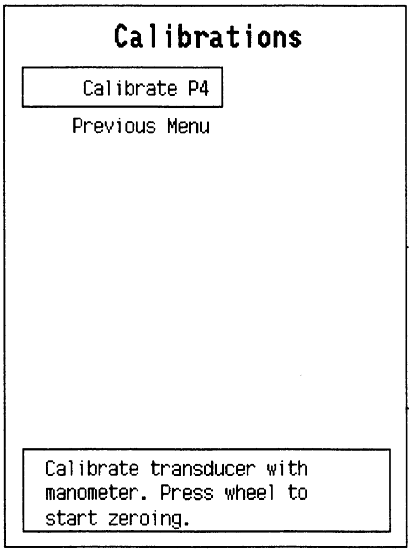
3.4.1 Cardiac output calibration

The cardiac output calibration can be performed only at the factory.

3.4.2 Invasive pressure calibration

Calibrate invasive pressure when the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter the ***COP*** service menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***)
2. Enter the ***Calibrations*** menu.



Calibrate transducer with manometer. Press wheel to start zeroing.

3. Connect a pressure transducer with a pressure manometer to the P4 connector. Select ***Calibrate P4*** from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg to 300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel.

   A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Cardiac Output

Problem	**Cause**	**What to do**
'NO CATHETER' message	Catheter or cable not connected.	Connect catheter (cable).
	Catheter or cable faulty.	Change catheter or cable.
	Blood temp out of range.	Check blood temp is within range.
'Tinj OFF' message	No injectate temp probe.	Connect probe.
	Probe faulty.	Change probe.
	Wrong type of probe.	Use Baxter compatible inj. temp probe.
	Temp out of range.	Check blood temp is within range.

4.1.2 SvO_2

Problem	**Cause**	**What to do**
Faulty cable	Factory calibration of the optical module corrupted.	Replace optical module.
	Red or infrared transmit error, currents cannot be adjusted to factory defaults.	
No cable	No optical module connected.	Connect optical module.
Insufficient signal	Loose catheter connection.	Check connection.
	Optical module failure.	Replace optical module.
	Catheter kinked or damaged.	Calibrate In vivo or replace catheter if necessary.
Warming up	Temperature of the optical module has not yet reached the optimum value or optical module failure or COPSv module failure.	Please wait. If it takes longer than 20 minutes replace optical module or COPSv module.
Poor SvO_2 signal	Signal pulsatility, wall contact or intensity shift signal quality level at 3.	Check number field message for problem 'Check catheter position' or 'Intensity shift'.

4.1.3 InvBP

Problem	**Cause**	**What to do**
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	To select the desired pressure waveforms, press **Monitor Setup** key and select modify waveforms.
		Check that the pressure transducer is open to the patient.
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P4 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to room air and zero the channel.
		Offset is > 150 mmHg. Open the transducer to room air and zero the channel.
		Defective transducer. Replace and zero the channel.
'Calibration failed' message	Unsuccessful calibrating of P4 (number field).	Pulsating waveform. Turn the transducer to sphygmomanometer and try again (zeroing takes place first).
		Gain is beyond the limits (±20% of the default gain) of the module. Replace the transducer.
Out of range ≤ 40 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel.
Out of range > 320 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel. The patient may also have high blood pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel.

See also the troubleshooting flowchart on the next page.

4.2 Troubleshooting flowchart

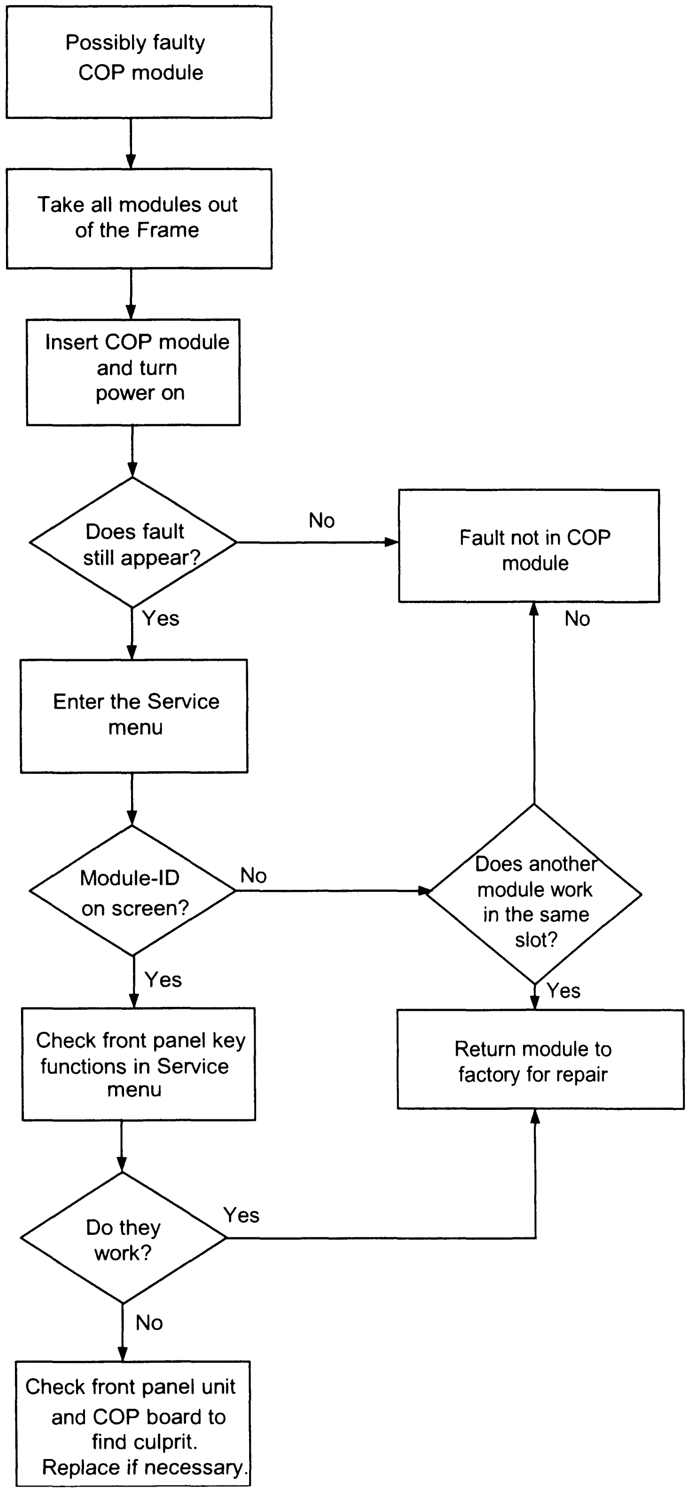

Possibly faulty COP module
Take all modules out of the Frame
Insert COP module and turn power on
Does fault still appear?
No
Fault not in COP module
Yes
Enter the Service menu
No
Module-ID on screen?
No
Does another module work in the same slot?
Yes
Yes
Check front panel key functions in Service menu
Return module to factory for repair
Do they work?
Yes
No
Check front panel unit and COP board to find culprit. Replace if necessary.

Figure 7 Cardiac Output Module troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ Cardiac Output Modules E-COPSv and E-COP.

APPENDIX A Service check form, Cardiac Output Modules, E-COP and E-COPSv (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	☐	☐	☐	6. Communication and memories	☐	☐	☐
Notes							
InvBP measurement							
7. Membrane key	☐	☐	☐	8. Cable and transducer detection	☐	☐	☐
9. Calibration	☐	☐	☐	10. Test with patient simulator	☐	☐	☐
Notes							
SvO_2 measurement							
11. Measurement state	☐	☐	☐	12. Calibration	☐	☐	☐
13. SvO2 messages	☐	☐	☐				
Notes							

C.O. measurement	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
14. Membrane key	☐	☐	☐	15. Test with patient simulator	☐	☐	☐
Notes							

All modules							
16. Electrical safety check	☐	☐	☐	17. Functioning after electrical safety check	☐	☐	☐
18. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

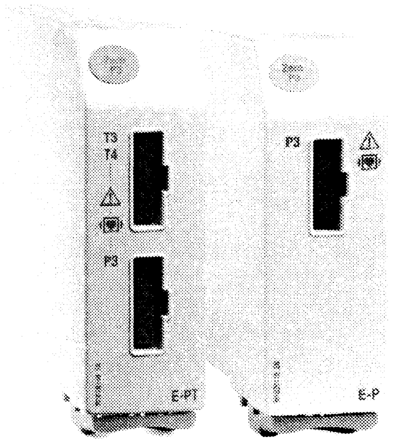
Signature

Datex-Ohmeda

Pressure Temp Module

S/5™ Pressure Temp Module, E-PT (Rev. 00)
S/5™ Pressure Module, E-P (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027826
June, 2005

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Appendix A: Service check form,
Pressure Temp Module, E-PT and Pressure Module, E-P (Rev. 00) A-1

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda Pressure Module, E-P, and Pressure Temp Module, E-PT. The E-P and E-PT modules are single width plug-in modules designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

Both modules provide invasive pressure measurement. Additionally, the E-PT-module provides temperature measurement.

NOTE: Do not use identical modules in the same monitoring system. The modules E-P/M-P and E-PT/M-PT are considered as identical modules.

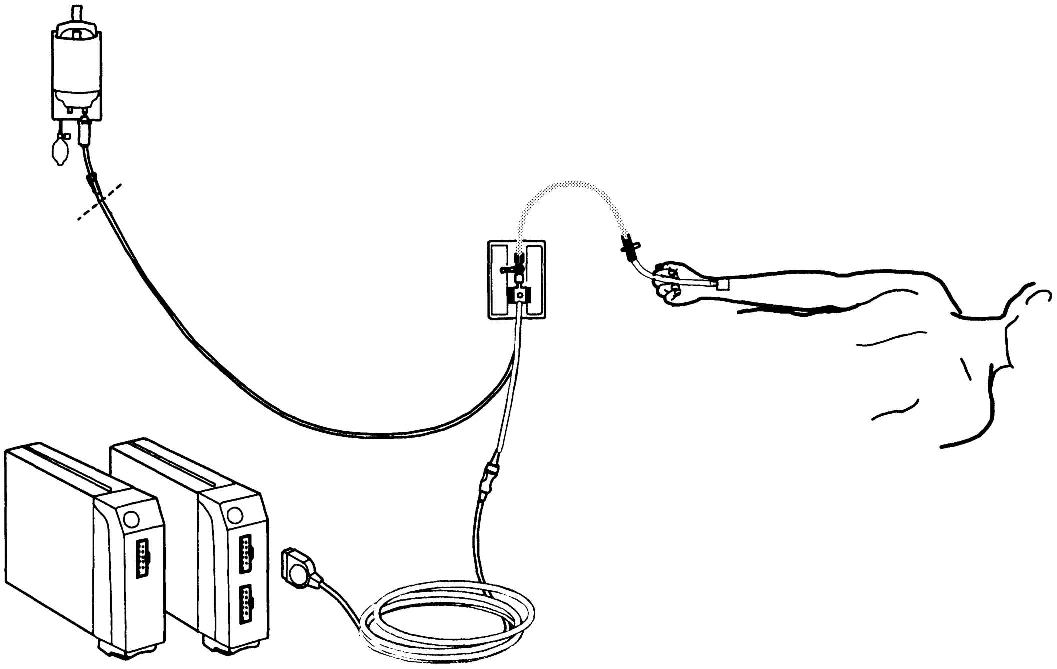


Figure 1 Invasive blood pressure setup

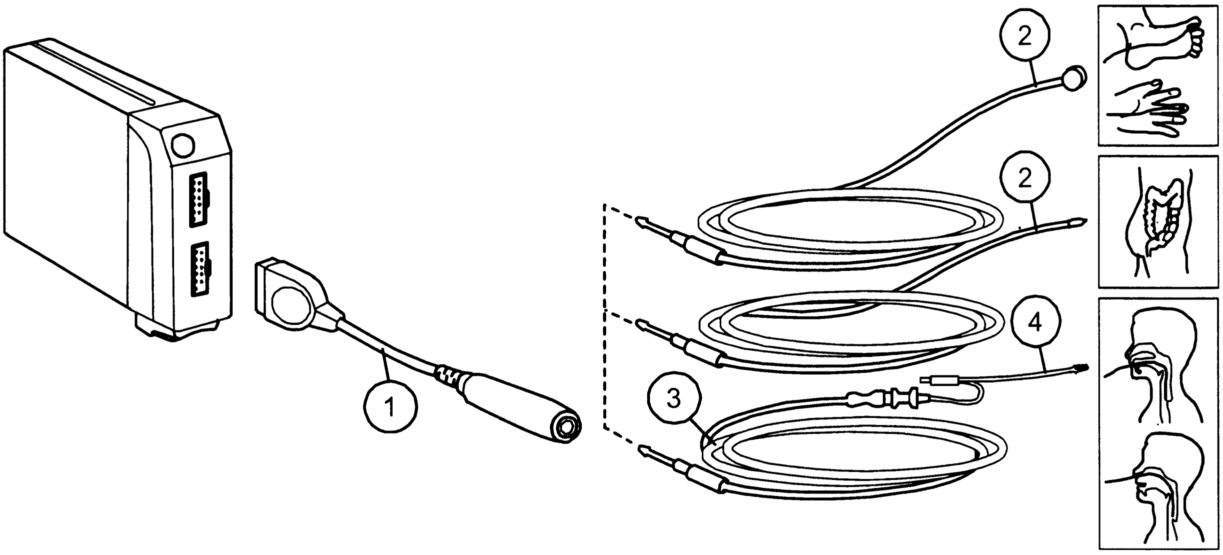


Figure 2 **Temperature measurement setup**

(1) Adapter cable for temperature probes
(2) Reusable temperature probe
(3) Adapter cable for disposable temperature probe
(4) Disposable temperature probe

Equipment safety symbols

⚠ When displayed on the E-P and E-PT modules, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

E-P	
Module size, W × D × H	37 × 186 × 112 mm / 1.5 × 7.3 × 4.4 in
Module weight	0.3 kg / 0.7 lb.
Power consumption	Approximately 3.5 W
E-PT	
Module size, W × D × H	37 × 187 × 112 mm / 1.5 × 7.4 × 4.4 in
Module weight	0.4 kg / 0.9 lb.
Power consumption	Approximately 3.5 W

1.2 Typical performance

1.2.1 InvBP

Measurement range	-40 to +320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%
Numerical display	
Range	-40 to +320 mmHg
Resolution	1 mmHg
Averaging	over 5 s, updated every 5 s, or end-expiratory filtering
Waveform display	
Range	-30 to +300 mmHg
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s
Pulse rate	
Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm

1.2.2 Temperature

Measurement range	10 to 45 °C (50 to 113 °F)
Measurement accuracy	±0.1 °C (25 to 45.0 °C) ±0.2 °C (10 to 24.9 °C)
Measurement accuracy with single-use probes	±0.2 °C (25 to 45.0 °C) ±0.3 °C (10 to 24.9 °C)
Display resolution	0.1 °C (0.2 °F)
Temperature self-check	at measurement start-up and then every 10 minutes

Probe type	Use only GE Healthcare temperature probes or defibrallator-proof YSI 400 series probes

1.3 Technical specifications

1.3.1 InvBP

Measurement accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 µV/V/mmHg
Input voltage	5VDC
Max current	20 mA
Filter	4 to 22 Hz adjustable (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	less than 15 sec.
Protection against electrical shock	type CF defibrillation proof

Numerical display averaging

Art and P1 numerical displays are averaged over 5 seconds and updated at 5 second intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

1.3.2 Temperature

Measurement accuracy	±0.1 °C (25.0 to 45.0 °C) ±0.2 °C (10.0 to 24.9 °C)
Protection against electrical shock	Type CF

NOTE: The accuracy of the measurement may be different from the specified, depending on transducer/probe used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

2.1.1 Invasive blood pressure

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.1.2 Temperature

The temperature is measured by a probe whose resistance varies when the temperature changes, called Negative Temperature Coefficient (NTC) resistor.

The resistance can be measured by two complementary methods:

- Applying a constant voltage across the resistor and measuring the current that flows through it.
- Applying a constant current to flow through the resistor and measuring the voltage that is generated across it.

In the S/5 module, the two methods are combined in the form of a voltage divider. The NTC resistor is connected in series with a normal resistor and a constant voltage is applied across them. The temperature dependent voltage can be detected at the junction of the resistors, thus producing the temperature signal from the patient. The signal is amplified by analog amplifiers and further processed by digital electronics.

2.2 Main components

The E-PT module consists of the following main parts:

- PT board
- Connector for temperature probes; temperature channels T3 and T4.
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.

The E-P module consists of the following main parts:

- PT board
- Connector for an invasive blood pressure sensor; invasive blood pressure channel P3.
- Key for pressure zeroing.

Communication between the module and the central unit is established through RS485 serial interface.

The power supply voltages to the module are generated in the power supply section of the monitor's Central Unit. All electrical connections between the module and the Central Unit are established via 25-pin D-type connector at the back of the module.

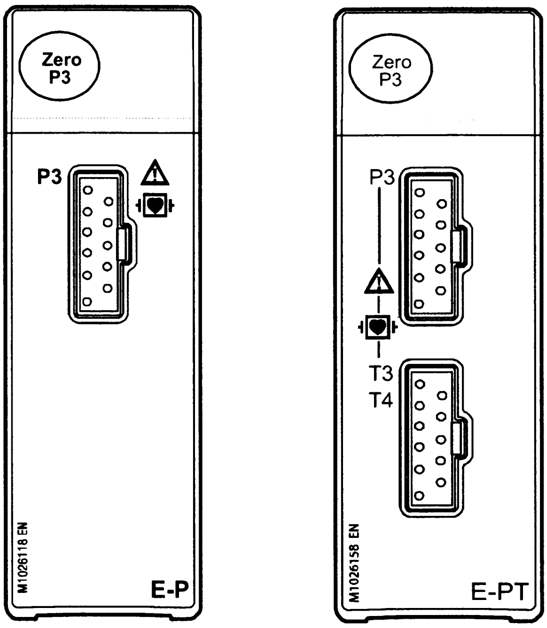

Zero
P3
P3
M1026118 EN
E-P
Zero
P3
P3
T3
T4
M1026158 EN
E-PT

Figure 3 **Front panel of E-P and E-PT Module**

2.2.1 PT board

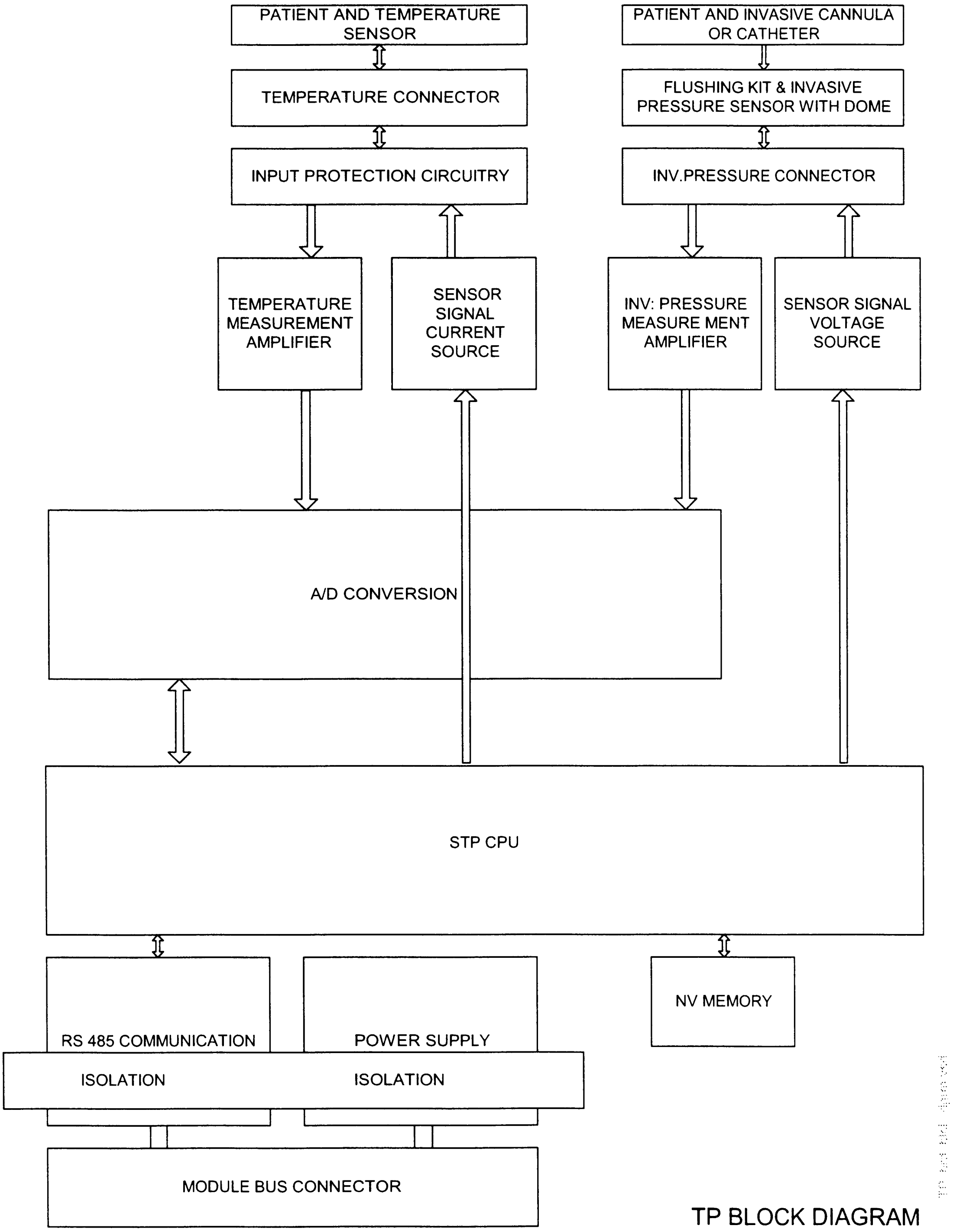

PATIENT AND TEMPERATURE SENSOR
TEMPERATURE CONNECTOR
INPUT PROTECTION CIRCUITRY
PATIENT AND INVASIVE CANNULA OR CATHETER
FLUSHING KIT & INVASIVE PRESSURE SENSOR WITH DOME
INV.PRESSURE CONNECTOR
TEMPERATURE MEASUREMENT AMPLIFIER
SENSOR SIGNAL CURRENT SOURCE
INV: PRESSURE MEASURE MENT AMPLIFIER
SENSOR SIGNAL VOLTAGE SOURCE
A/D CONVERSION
STP CPU
RS 485 COMMUNICATION
POWER SUPPLY
NV MEMORY
ISOLATION
ISOLATION
MODULE BUS CONNECTOR
TP BLOCK DIAGRAM

Figure 4 **PT board block diagram**

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Temperature measurement unit

The NTC-resistor value in the probe depends on the patient's temperature. It is measured with the following principle described below.

The constant current source is supplied about current through the temperature sensor (YSI 400-series NTC resistor). The constant current is caused a voltage over the temperature sensor (NTC resistor). The voltage over the temperature sensor is amplified in a differential amplifier stage. The amplified voltage is transferred to a controller of the PT board through an A/D converter.

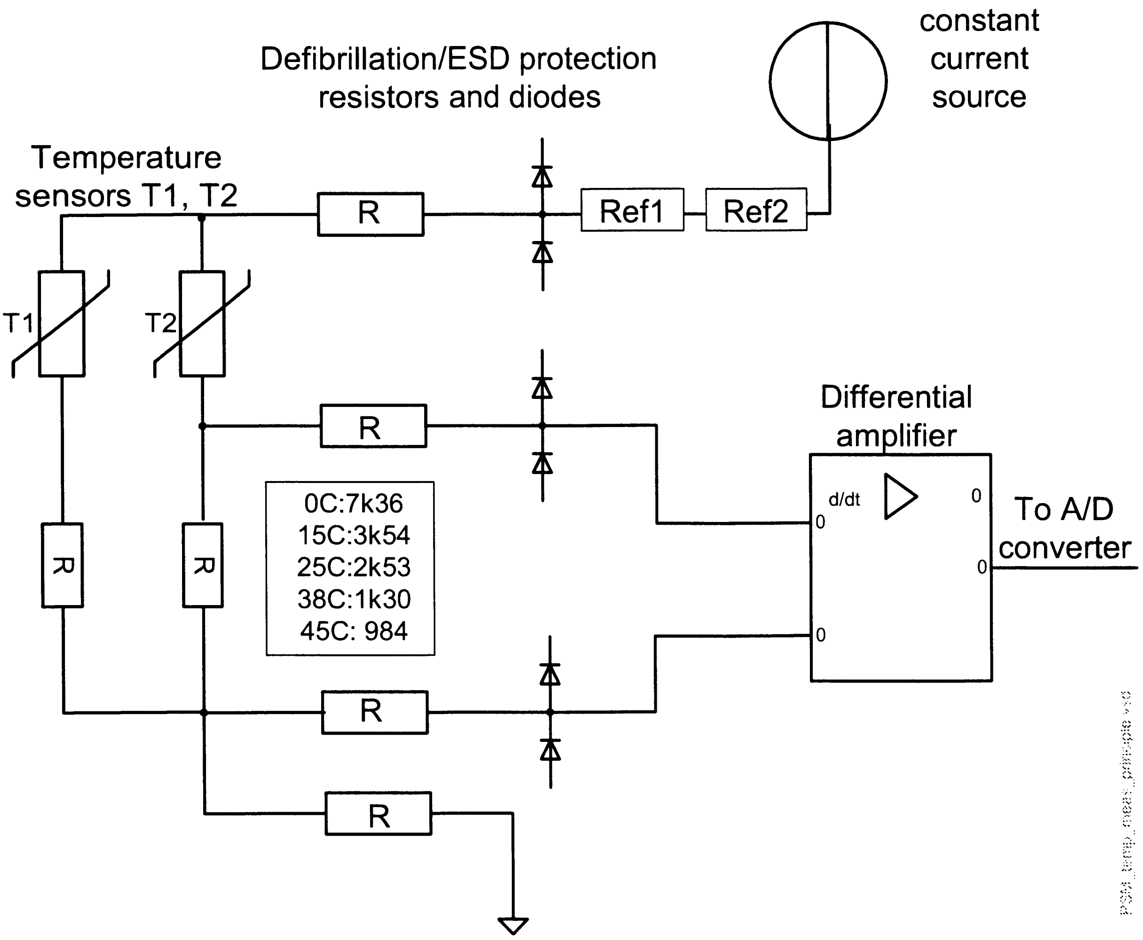

Defibrillation/ESD protection resistors and diodes
constant current source
Temperature sensors T1, T2
R
Ref1
Ref2
T1
T2
Differential amplifier
d/dt
0
0
0
0
To A/D converter
0C:7k36
15C:3k54
25C:2k53
38C:1k30
45C: 984
R
R
R
R
R

Figure 5 **Temperature measurement principle**

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

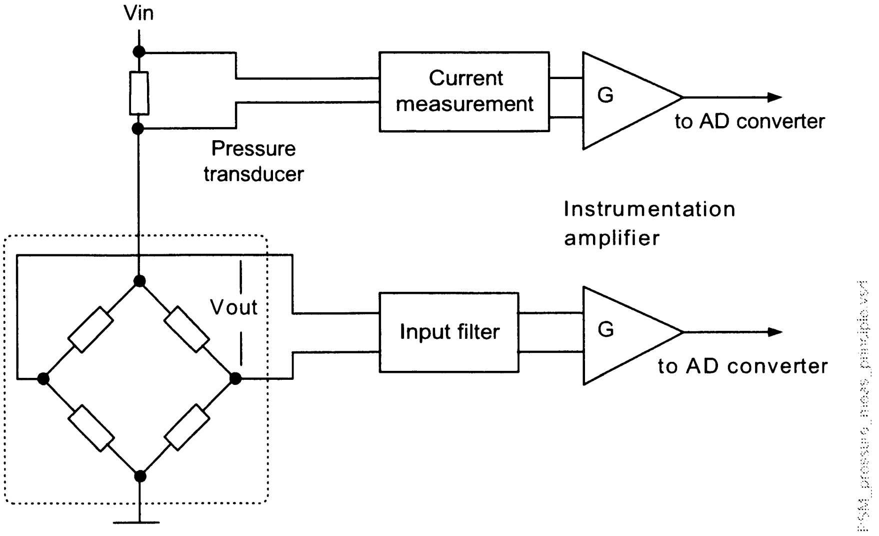

Vin
Current measurement
G
to AD converter
Pressure transducer
Instrumentation amplifier
Vout
Input filter
G
to AD converter
PSM_pressure_meas_principle.vsd

Figure 6 Pressure measurement principle

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. Data transmission rate is 500kbps.

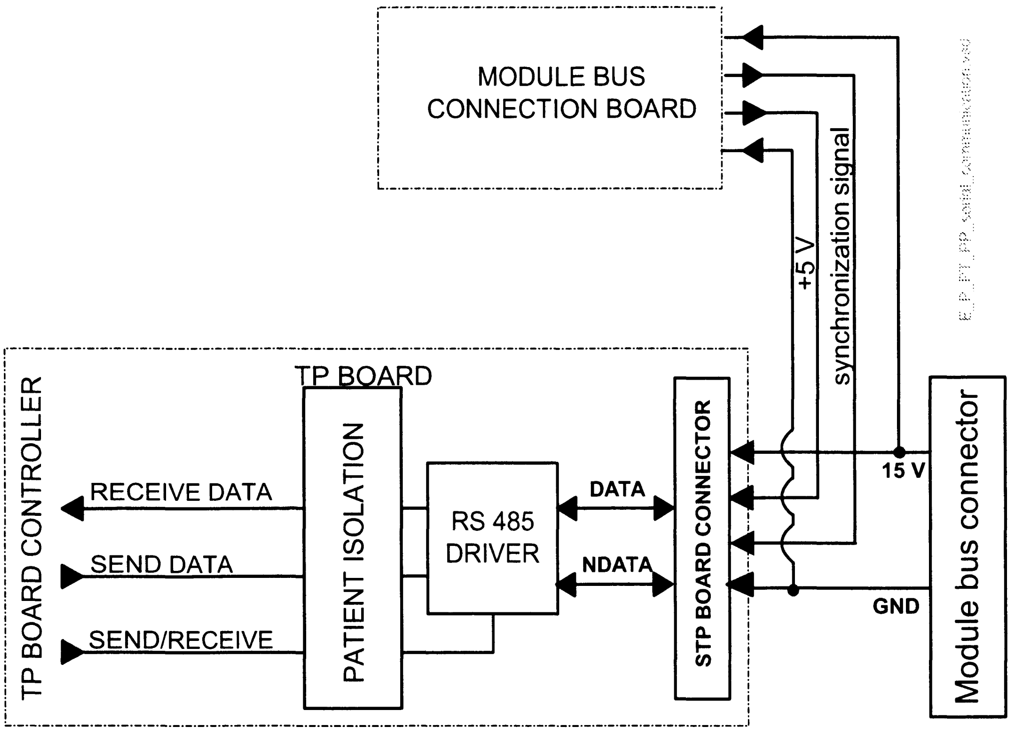

MODULE BUS CONNECTION BOARD
+5 V
synchronization signal
E_P_PT_PP_serial_communication.vsd
TP BOARD CONTROLLER
TP BOARD
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
STP BOARD CONNECTOR
15 V
GND
Module bus connector

Figure 7 Serial communication of P/PT module

Signals and isolation barrier

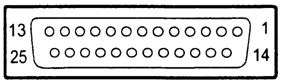
The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

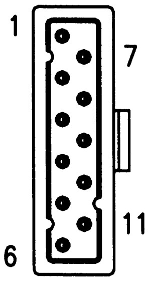
The power for the electronics on the floating part of the PT/P board is made with the switching power supply connected to a high voltage isolated transformer. The switching power supply on the PT board is synchronized to the frequency, about 340kHz of the switching power supply on the Module bus connection board. The Module bus connection board supplies non-isolated 5 V to the PT board. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. The measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

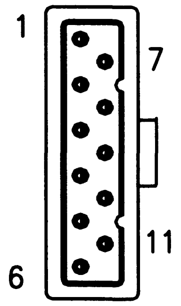
2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	3	I	+15 VD
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	GND
	13		GND
	15	I	GND
	21	O	PWM_ECG
	Other	NC	Not Connected

2.3.2 Invasive blood pressure connector

Invasive blood pressure connector (P3)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage
	2	BP SIG+	BP transducer signal positive (+)
	3	NC	Not connected
	4	AGND	Analog ground
	5	NC	Not connected
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-)
	9	NC	Not connected
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

2.3.3 Temp connector

Temp connector (T1, T2)	**Pin No.**	**Signal**
	1	Sensor drive current
	2	Input from temperature sensor, channel 1
	3	Not connected
	4	Not connected
	5	Thermistor ID (LOW= Temperature error, HIGH=YSI 400 series)
	6	Cable shield
	7	Analog ground
	8	Input from temperature sensor, channel 2
	9	Not connected
	10	Not connected
	11	

3 Service procedures

3.1 General service information

The field service of the E-P and E-PT modules is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check list should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**For product(s)**
Patient simulator		
Adapter cables for simulators:		
- Dual temperature adapter cable	402015-004	Hemodynamic patient simulator and Medsim
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Temperature adapter cable	M1010832	Medsim
- Inv.BP adapter cable	M1010858	Medsim
- Temperature adapter cable	M1010846	Lionheart & MPS450
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Accessories:		
Pressure manometer		Hemodynamic modules w/ (P)
Temperature test set	884515	Hemodynamic modules w/ (T)
InvBP transducer		
Oscilloscope		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - there are no loose objects inside the module

   ✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1*** - ***ECG1***
Field 2 - ***P1***
Field 3 - ***P3***
Field 4 - ***P5***
Digit Fields
Field 4 - ***T3+T4***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

   ✍

   Preset InvBP measurement settings:

   Invasive Pressures - ***P1 'Art' Setup*** - ***Label*** - ***Art***
   P3 Setup - ***Label*** – ***PA***

4. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** - (password 26-23-8)

Take down the information regarding module software by selecting ***Scroll vers*** and turning the ComWheel.

✍

5. Communication and memories

   Enter the ***P/PT*** service menu (according to the tested module):

   Parameters - P/PT

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the module memories have passed the internal memory test, i.e. the RAM, ROM and EEPROM show all OK.

   ✍

Invasive blood pressure measurement

6. Membrane key

   Check the front panel membrane key **Zero P3**.

   Press the key at least for one second. Check that the pressed key is identified, i.e. the text for Button changes from OFF to ON in the service menu.

   ✍

7. Cable and transducer detection

   Check that the Cable and Probe show OFF.

   Plug a cable with an invasive blood pressure transducer into the front panel connector P3.

   Check that Cable and Probe show ON and the corresponding pressure waveform field appears on the monitor screen.

NOTE: Test both invasive blood pressure channels with E-PP.

✍

8. Calibration

   Calibrate the InvBP channel according to the instructions in section "Invasive pressure calibration".

   ✍

9. Configuration BP/PT

   Check that the module configuration is correct with P and PT modules.

   The configuration in use is shown beside the text Configuration in the service menu and it can be either BP or PT.

   Change the configuration in the ***Calibrations*** menu, if necessary.

   ✍

10. Test with patient simulator

    Check the InvBP channels with a patient simulator.

The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

SENSITIVITY switch position: 5 µV/V/mmHg
ECG - BASE - BPM - 60
BP - 3 - WAVE - PA

Connect a cable from the channel BP2 to the connector P3.

Check that appropriate InvBP waveform is shown and the InvBP value is approximately 25/10 (±2 mmHg).

✍

Modules with temperature measurement

11. Temperature probe detection

    Check that the Cable and Probe show OFF for the channels T3 and T4 when no probes are connected.

    Connect a temperature test plug into the connector T3. Check that the Cable and Probe for T3 show ON and the corresponding temperature value appears on the screen.

    Perform the same check also for the channel T4.

    ✍

12. Calibration check

    Check the temperature calibrations using temperature test plugs.

    If the deviation on a temperature reading on the screen is more then 0.1 °C, calibrate the temperature channels according to the instructions in section "Temperature calibration".

    ✍

13. Temp test function

    Activate the temperature test by selecting ***Temp Test*** from the menu and pressing the ComWheel twice. When the message 'Performing temp test' disappears from the digit field for T3+T4, check that no error messages appear and Temp error shows OFF for both channels in the menu.

    ✍

All modules

14. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

15. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

    ✍

16. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

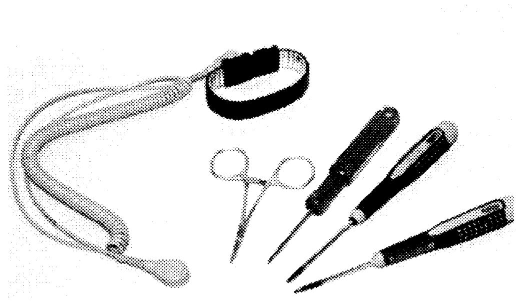
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-P and E-PT modules (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To remove the PT board: remove the four screws (T10) with nylon washers holding the board to the body. Disconnect the PT input connector and the internal module bus connector.
4. To remove the Module bus connection board: remove the two screws (T10) with nylon washers holding the PC board to the body plate and the two screws (T10) holding the module bus connector to the body plate.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: Remember to reassemble the nylon washers.

CAUTION When reassembling the module, make sure that all cables are connected properly.

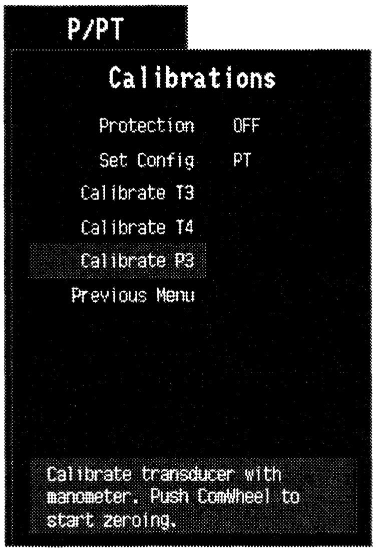
Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 Invasive pressure calibration

Perform pressure calibration whenever the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter ***P/PT*** service menu: **Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***
2. Enter ***Calibrations*** menu.



Protection OFF

Set Config PT

Calibrate transducer with manometer. Push ComWheel to start zeroing.

3. Connect a pressure transducer with a pressure manometer to the P3 connector. Select ***Calibrate P3***. Leave the transducer to room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of ±1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

3.4.2 Temperature calibration

NOTE: For the temperature calibration, separate calibration plugs (25 °C and 45 °C) are necessary. A test set of two plugs is available from GE Healthcare, order code 884515.

Perform temperature calibration whenever the measured values deviate more than ±0.1.

1. Enter ***P/PT*** service menu (**Monitor Setup**, ***Install/Service, Service, Parameters***).
2. Enter ***Calibrations*** menu.
3. Select ***Protection*** OFF.
4. Select ***Calibrate T3/Calibrate T4***.
5. Insert the calibration plug (25 °C) into T3/T4 connector.
6. Press the ComWheel.
7. Insert the calibration plug (45 °C) into T3/T4 connector.

8. Press the ComWheel.
9. Select ***Protection*** ON.

4 Troubleshooting

4.1 Troubleshooting chart

See also the "User's Reference Manual" for more troubleshooting procedures.

4.1.1 Invasive blood pressure

Problem	**Cause**	**What to do**
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check transducer.
	No pressure module plugged in.	Check the module.
	No waveform selected on screen.	Check selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms. Check that pressure transducer open to patient.
'Not zeroed' message	Measurement on, channel not zeroed.	Zero the channel.
'Zeroing failed' message	Unsuccessful zeroing of P3 (number field).	Possibly due to pulsating pressure waveform. Open the transducer to air and zero the channel. Offset is > 150 mmHg. Open the transducer to air and zero the channel. Defective transducer. Replace it and zero the channel.
'Calibration failed' message	Unsuccessful calibrating of P3 (number field), possibly due to pulsating waveform.	Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Gain is beyond the limits (±20% of the default gain). Replace the transducer.
Out of range ≤40 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel.
Out of range >320 mmHg	Measurement pressure is beyond measurement range.	Check transducer level. Zero the channel. The patient may also have high pressure.
Zero adj. >100 mmHg	Offset when zeroing is >100 mmHg (but <150 mmHg) from the absolute zero of the module (with default gain).	Check transducer. The waveform may hit the top and the numeric display not shown.
Out of range	Measured pressure is beyond the internal measurement range of the module.	The waveform hits the top and the numeric display not shown. Check transducer and its level. Zero the channel.

4.1.2 Temperature

Problem	Cause	What to do
'Temperature error' message	Faulty calibration.	Perform calibration. If it does not help, check that front panel connectors are properly connected to PT board.
No temperature displayed	Wrong type of probe. Temperature out of measurable range. Temperature calibration not protected.	Use correct probe. The range is between 10 and 45 °C. Select ***Protection*** ON in the service menu.

4.2 Troubleshooting flowchart

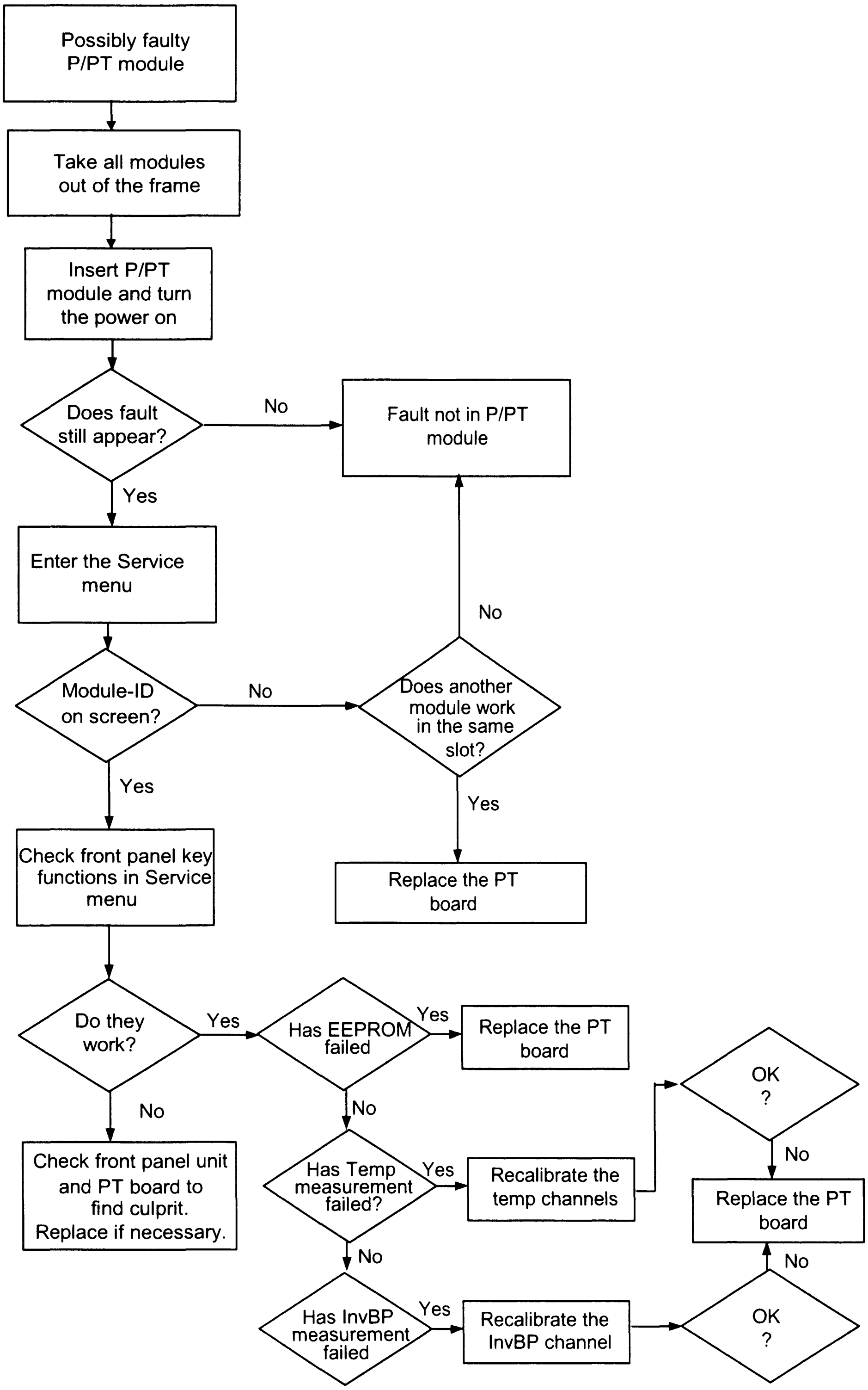

Possibly faulty P/PT module
Take all modules out of the frame
Insert P/PT module and turn the power on
Does fault still appear?
No
Fault not in P/PT module
Yes
Enter the Service menu
No
Module-ID on screen?
No
Does another module work in the same slot?
Yes
Yes
Check front panel key functions in Service menu
Replace the PT board
Do they work?
Yes
Has EEPROM failed
Yes
Replace the PT board
No
No
OK ?
Check front panel unit and PT board to find culprit. Replace if necessary.
Has Temp measurement failed?
Yes
Recalibrate the temp channels
No
Replace the PT board
No
No
Has InvBP measurement failed
Yes
Recalibrate the InvBP channel
OK ?

Figure 8 Troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5™ Pressure Temp Module, E-PT, and/or the S/5™ Pressure Module, E-P.

APPENDIX A Service check form, Pressure Temp Module, E-PT and Pressure Module, E-P (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐				
4. Module software	P						
	PT						
5. Communication and memories	☐	☐	☐				
Notes							
InvBP measurement							
6. Membrane key	☐	☐	☐	7. Cable and transducer detection	☐	☐	☐
8. Calibration	☐	☐	☐	9. Configuration BP/PT	☐	☐	☐
10. Test with patient simulator	☐	☐	☐				
Notes							

TEMP measurement	OK	N.A.	Fail		OK	N.A.	Fail
11. Temperature probe detection	☐	☐	☐	12. Calibration check	☐	☐	☐
13. Temp test function	☐	☐	☐				
Notes							
All modules							
14. Electrical safety check	☐	☐	☐	15. Functioning after electrical safety check	☐	☐	☐
16. Final cleaning	☐	☐	☐				
Notes							

Notes

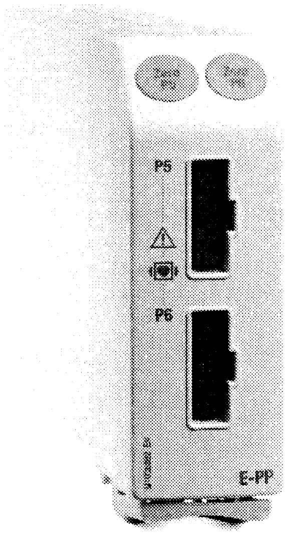
Used spare parts			

Signature

Datex-Ohmeda

S/5^{TM} Dual Pressure Module, E-PP (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027827
June, 2005

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Appendix A: Service check form, Dual Pressure Module, E-PP (Rev. 00) A-1

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Dual Pressure Module, E-PP. The E-PP module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. The Dual Pressure Module provides invasive blood pressure (InvBP) measurement. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

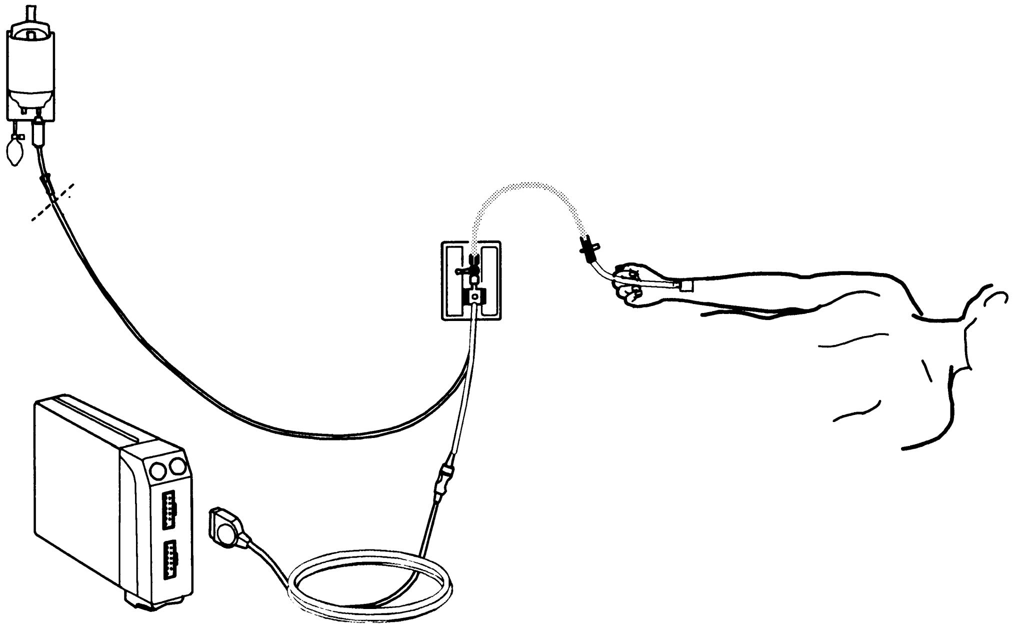


Figure 1 Invasive blood pressure setup

Monitor software compatibility

The Dual Pressure Module, E-PP, functions only with monitor software of level 97 and later.

Equipment safety symbols

⚠ When displayed on the E-PP module, indicates that protection against cardiac defibrillator discharge is due in part to the accessories for pulse oximetry (SpO2), temperature (T) and invasive pressure (P) measurement.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 x 186 x 112 mm / 1.5 x 7.3 x 4.4 in
Module weight	0.3 kg / 0.7 lb.
Power consumption	approximately 3.5 W

1.2 Typical performance

Measurement range	-40 to +320 mmHg
Measurement accuracy	±5% or ±2 mmHg
Zero adjustment range	±150 mmHg
Calibration range	±25%

Numerical display

Range	-40 to +320 mmHg
Resolution	1 mmHg
Averaging	over 5 s, updated every 5 s, or end-expiratory filtering

Waveform display

Range	-30 to +300 mmHg
Scales	Upper limit is adjustable between 10 and 300 mmHg in steps of 10. Lower limit is 10% of selected upper limit below zero.
Sweep speed	12.5, 25, 50 mm/s

Pulse rate

Measurement range	30 to 250 bpm
Resolution	1 bpm
Accuracy	±5% or ±5 bpm

1.2.1 Technical specifications

Accuracy	±5% or ±2 mmHg
Transducer sensitivity	5 μV/V/mmHg
Filter	4 to 22 Hz adjustable (-3 dB)
Zero set accuracy	±1 mmHg
Calibration resolution	±1 mmHg
Zero time	< 15 s
Protection against electrical shock	type CF defibrillation proof

Numerical display averaging

Art and P1 numerical displays are averaged over 5 seconds and updated at 5 second intervals. All other pressures have respiration artifact rejection.

NOTE: The accuracy of the measurement may be different from that specified, depending on the transducer/probe being used. Please check the transducer/probe specification.

2 Functional description

2.1 Measurement principle

To measure invasive blood pressure, a catheter is inserted into an artery or vein. The invasive pressure setup, consisting of connecting tubing, pressure transducer, an intravenous bag of normal saline all connected together by stopcocks, is attached to the catheter. The transducer is placed at the same level with the heart, and is electrically zeroed.

The transducer is a piezo-resistive device that converts the pressure signal to a voltage. The monitor interprets the voltage signal so that pressure data and pressure waveforms can be displayed.

2.2 Main components

The main components of the Dual Pressure Module, E-PP, are an STP circuit board, a front panel and a box. The front panel includes two connectors, P5 and P6, and two direct function keys, **Zero P5** and **Zero P6** for pressure zeroing.

Communication between the Dual Pressure Module and the Central Unit is established via an RS485 serial interface.

The power supply voltages to the Dual Pressure Module are generated in the power supply section of the Central Unit. All electrical connections between the Dual Pressure Module and the Central Unit are provided via a 25-pin D-connector at the back of the module.

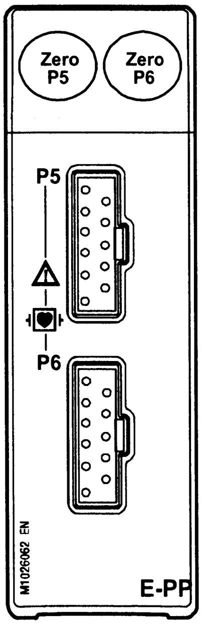


Figure 2 **Front panel of the Dual Pressure Module, E-PP**

2.2.1 STP board

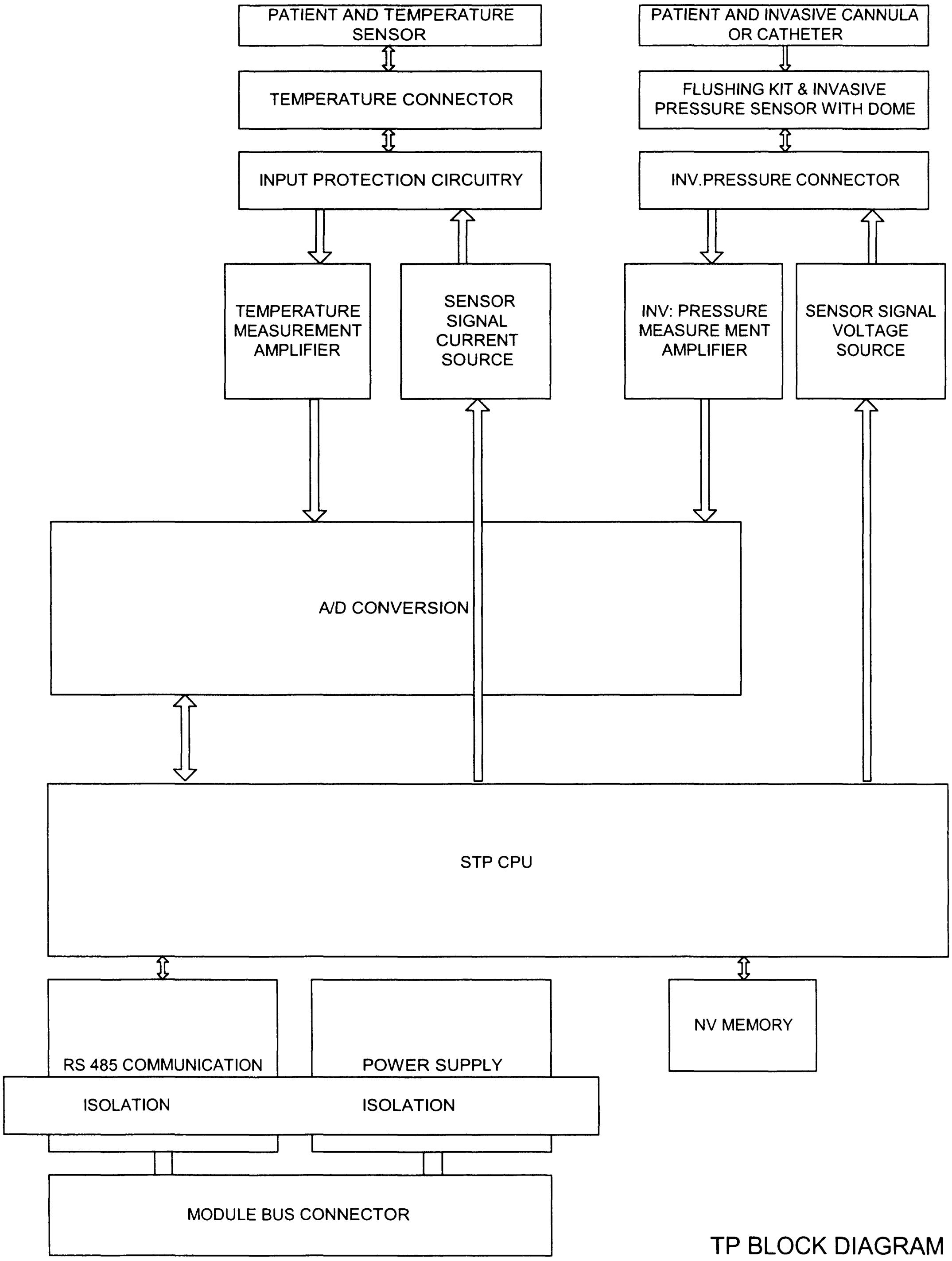

PATIENT AND TEMPERATURE SENSOR
TEMPERATURE CONNECTOR
INPUT PROTECTION CIRCUITRY
TEMPERATURE MEASUREMENT AMPLIFIER
SENSOR SIGNAL CURRENT SOURCE
PATIENT AND INVASIVE CANNULA OR CATHETER
FLUSHING KIT & INVASIVE PRESSURE SENSOR WITH DOME
INV.PRESSURE CONNECTOR
INV: PRESSURE MEASURE MENT AMPLIFIER
SENSOR SIGNAL VOLTAGE SOURCE
A/D CONVERSION
STP CPU
RS 485 COMMUNICATION
POWER SUPPLY
NV MEMORY
ISOLATION
ISOLATION
MODULE BUS CONNECTOR
TP BLOCK DIAGRAM

Figure 3 Temperature and invasive pressure measurements on STP board

Microprocessor unit

The CPU is a 16 bit H8/3052 single-chip microcomputer. It contains 128 kbytes of flash memory and 4 kbytes of RAM. The clock frequency is 16 MHz.

High speed I/O is used to obtain pulse control sequence necessary for pulse oximetry measurement. Timing for the clock is from the oscillator.

Invasive blood pressure measurement unit

An isolated +5 V voltage is supplied to the pressure transducer. The differential voltage, which depends on the pressure and the supplied voltage, is calculated from the bridge connection (see the formula below).

$U_{out} = U_{in} \times \text{pressure} \times 5\ \mu V$, where U_{in} is 5 V

$\Rightarrow U_{out} = 25\ \mu V \times \text{pressure [mmHg]}$

Pressure amplification is realized in the instrumentation amplifier. The gain of the amplifier is set to keep the level of the signal transferred to A/D converter within the measurement range even when there are circumstantial offsets or offsets caused by the transducer. There is a filter before the amplifier to attenuate high frequency disturbances.

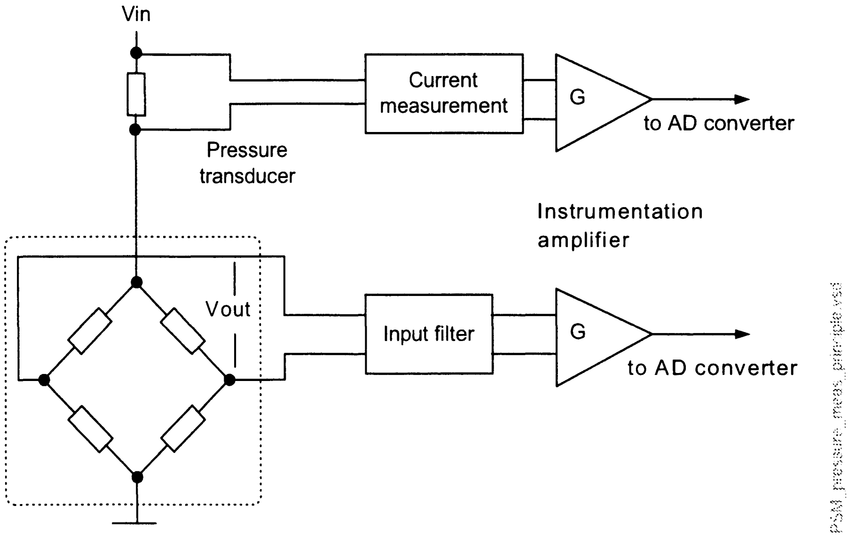

Vin
Current measurement
G
to AD converter
Pressure transducer
Instrumentation amplifier
Vout
Input filter
G
to AD converter
PSM_pressure_meas_principle.vsd

Figure 4 **Pressure measurement principle**

Serial communication

An RS485 type bus driver makes the serial communication between the module and the frame. Data transmission rate is 500kbps.

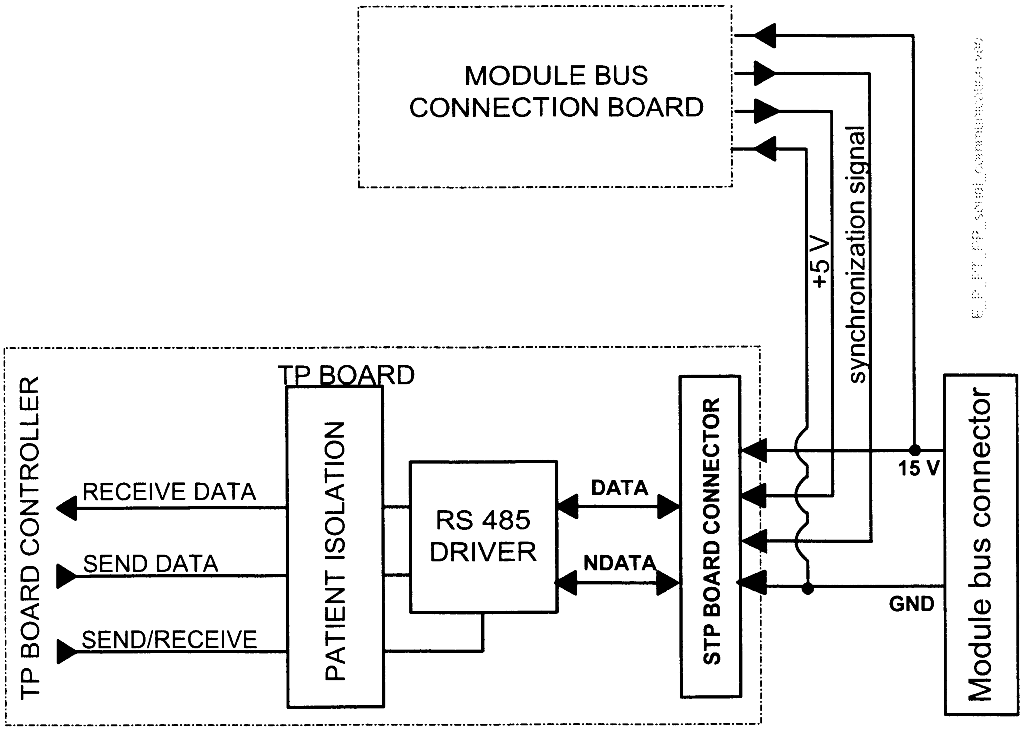

MODULE BUS CONNECTION BOARD
+5 V
synchronization signal
TP BOARD
TP BOARD CONTROLLER
RECEIVE DATA
SEND DATA
SEND/RECEIVE
PATIENT ISOLATION
RS 485 DRIVER
DATA
NDATA
STP BOARD CONNECTOR
15 V
GND
Module bus connector

Figure 5 Serial communication of PP module

Signals and isolation barrier

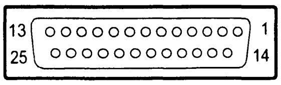
The communication signals transfer over the isolation barrier by using high isolation voltage (6kV) opto isolators.

Power supply section

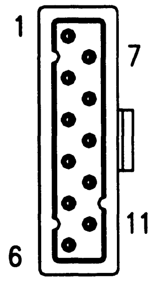
The power for the electronics on the floating part of the STP board is made with the switching power supply connected to a high voltage isolated transformer. The switching power supply on the PT board is synchronized to the frequency, about 340kHz of the switching power supply on the Module bus connection board. The Module bus connection board supplies non-isolated 5 V to the PT board. The module uses only Vmod 13.8 - 16 V voltage of the frame. The other voltages of the measuring boards are made by the switching power supplies and regulators or the linear regulators. The measuring board is protected against overloading with PTC type automatic fuses.

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	3	I	+15 VD
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	GND
	13		GND
	15		GND
	21	O	PWM_ECG
	Other	NC	Not Connected

2.3.2 Invasive blood pressure connectors

Invasive blood pressure connectors (P5, P6)	Pin No.	Signal	Description
	1	BP_+V_{REF}	BP transducer excitation voltage
	2	BP SIG+	BP transducer signal positive (+)
	3	NC	Not connected
	4	AGND	Analog ground
	5	NC	Not connected
	6	SHIELD	BP cable shield
	7	AGND	Analog ground
	8	BP SIG1	BP transducer signal negative (-)
	9	NC	Not connected
	10	BP1_ID	BP1 probe identification
	11	NC	Not connected

3 Service procedures

3.1 General service information

The field service of the Dual Pressure Module, E-PP, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**For product(s)**
Patient simulator		
Adapter cables for simulators		
- Dual Inv.BP adapter cable	2005772-001	Hemodynamic patient simulator
- Inv.BP adapter cable	M1010858	Medsim
- Inv.BP adapter cable	M1010862	Lionheart & MPS450
Accessories:		
Pressure manometer		Hemodynamic modules w/ (P)
InvBP transducer		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

- screws are tightened properly
- cables are connected properly
- there are no loose objects inside the module

✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - all connectors are intact and are attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup* - *Waveform Fields* - *Field 4* - *P5***
Field 5* - *P6

3. Installation

   Plug in the module, E-PP. Check that it goes in smoothly and locks up properly.

   ✍

   Preset the InvBP measurement settings:

   Invasive Pressures - ***P5 Setup* - *Label* - *P5***
   P6 Setup* - *Label* - *P6

4. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service (password 16-4-34)* - *Service View (password 26-23-8)***

   Take down the information regarding the PP module software by selecting ***Scroll vers*** and turning the ComWheel.

   ✍

5. Communication and memories

   Enter the PP module service menu:

   Modules* - *PP

Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all show OK.

✍

6. Membrane keys

   Check the front panel membrane keys **Zero P5** and **Zero P6**.

   Press each of the keys for at least one second. Check that the key being pressed is identified, i.e. the text on the service menu for Button changes from OFF to ON.

   ✍

7. Cable and transducer detection

   Check that Cable and Probe show OFF.

   Plug the cable from an invasive blood pressure transducer into the front panel connector P5. Check that Cable and Probe show ON and the corresponding pressure waveform field appears on the monitor screen.

   ✍

8. Calibration

   Calibrate the InvBP channels according to the instructions in section "Invasive pressure calibration".

   ✍

9. Test with patient simulation

   Check the InvBP channels with a patient simulator.

   The settings and checks with a Dynatech Nevada medSim 300 Patient Simulator are:

   SENSITIVITY switch position: 5 µV/V/mmHg
   ECG - BASE - BPM - 60
   BP - 2 - WAVE - ATM
   3 - WAVE - ATM

   Connect channel BP2 to connector P5 and channel BP3 to connector P6.

   Zero the InvBP channels by pressing the zeroing keys on the module front panel.

   BP - 2 - WAVE - CVP
   3 - WAVE - PA

   Check that appropriate InvBP waveforms are shown and the InvBP values are approximately 15/10 mmHg (±2 mmHg) for channel P5 and 25/10 (±2 mmHg) for channel P6.

   ✍

10. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

11. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

12. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

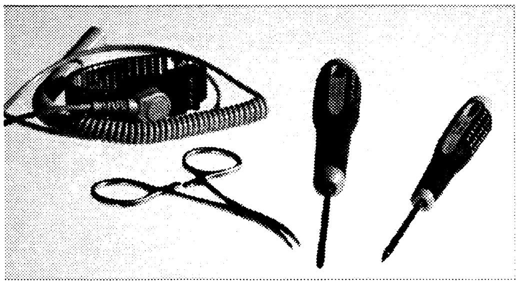
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the Dual Pressure Module, E-PP (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To remove the SPT board: remove the four screws (T10) with nylon washers holding the board to the body. Disconnect the TP input connector and the internal module bus connector.
4. To remove the Module bus connection board: remove the two screws (T10) with nylon washers holding the PC board to the body plate and the two screws (T10) holding the module bus connector to the body plate.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

NOTE: Remember to reassemble the nylon washers.

CAUTION When reassembling the module, make sure that all cables are connected properly.

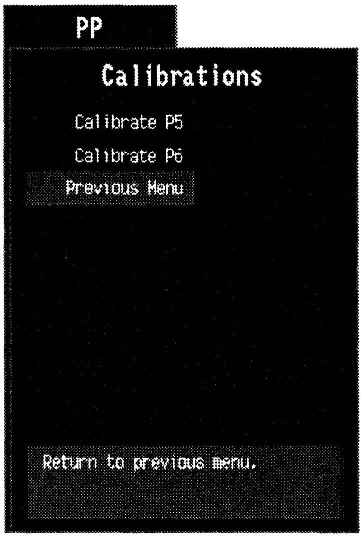
Always perform the "Service check" after reassembling the module.

3.4 Adjustments and calibrations

3.4.1 Invasive pressure calibration

Perform a pressure calibration whenever the pressure transducer (probe) is replaced with a different type of transducer.

1. Enter the ***PP*** service menu (**Monitor Setup** - ***Install/Service*** - ***Service*** - ***Parameters***).
2. Enter the ***Calibrations*** menu.



Return to previous menu.

3. Connect a pressure transducer with a pressure manometer to the P5/P6 connector. Select ***Calibrate P5*** or ***Calibrate P6*** from the menu. Leave the transducer at room air pressure.
4. Press the ComWheel to start zeroing.
5. Supply a pressure of 100 mmHg...300 mmHg to the transducer. The recommended pressure is 200 mmHg.
6. Set the pressure on the display to match the pressure reading on the manometer and press the ComWheel. A tolerance of 1 mmHg is allowed.
7. The text 'calibrated' appears on the display.

4 Troubleshooting

See also the “User's Reference Manual” for more troubleshooting procedures.

4.1 Troubleshooting chart

Problem	Cause	What to do
Abnormally low pressure	Transducer wrongly positioned.	Check mid-heart level and reposition transducer.
No pressure	Defective transducer.	Check the transducer.
	No pressure module plugged in.	Check the module.
	No selected waveform on screen.	Check selected pressure waveforms by pressing **Monitor Setup** key and selecting modify waveforms. Check that pressure transducer open to patient.
‘Not zeroed’ message	Measurement on, channel not zeroed.	Zero the channel.
‘Zeroing failed’ message	Unsuccessful zeroing of P5/P6 (number field), possibly due to pulsating pressure waveform. Offset is > 150 mmHg. Defective transducer.	Open the transducer to air and zero the channel. Open the transducer to air and zero the channel. Replace the transducer and zero the channel.
‘Calibration failed’ message	Unsuccessful calibration of P5/P6 (number field), possibly due to pulsating waveform. Gain is beyond the limits (± 20% of the default gain).	Turn the transducer to sphygmomanometer and try again (zeroing takes place first). Replace the transducer.
Out of range ≤ 40 mmHg	Pressure measurement is beyond measurement range.	Check the transducer level. Zero the channel.
Out of range > 320 mmHg	Pressure measurement is beyond measurement range.	Check the transducer level. Zero the channel. The patient may also have high blood pressure.
Zero adj. > 100 mmHg	Offset when zeroing is > 100 mmHg (but < 150 mmHg) from the absolute zero of the module (with default gain). The waveform may hit the top of the screen and the numeric display not shown.	Check the transducer.
Out of range	Measured pressure is beyond the internal measurement range of the module. The waveform may hit the top of the screen and the numeric display not shown.	Check the transducer and its level. Zero the channel.

4.2 Troubleshooting flowchart

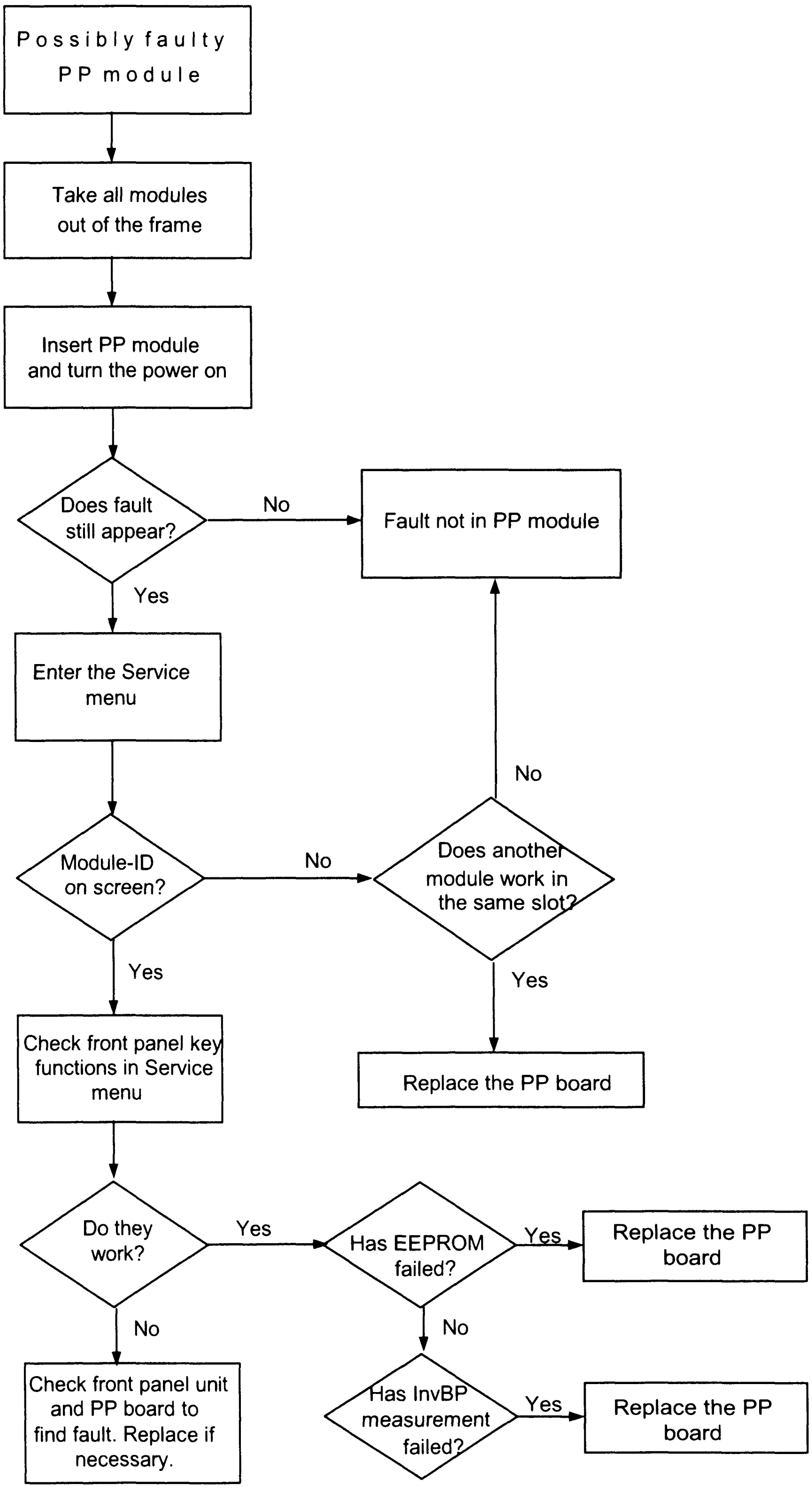

Possibly faulty PP module
Take all modules out of the frame
Insert PP module and turn the power on
Does fault still appear?
No
Fault not in PP module
Yes
Enter the Service menu
No
Module-ID on screen?
No
Does another module work in the same slot?
Yes
Yes
Check front panel key functions in Service menu
Replace the PP board
Do they work?
Yes
Has EEPROM failed?
Yes
Replace the PP board
No
No
Check front panel unit and PP board to find fault. Replace if necessary.
Has InvBP measurement failed?
Yes
Replace the PP board

Figure 6 E-PP troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} Dual Pressure Module, E-PP.

APPENDIX A Service check form, Dual Pressure Module, E-PP (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐				
4. Module software	PP						
5. Communication and memories	☐	☐	☐				
6. Membrane keys	☐	☐	☐	7. Cable and transducer detection	☐	☐	☐
8. Calibration	☐	☐	☐	9. Test with patient simulation	☐	☐	☐
10. Electrical safety check	☐	☐	☐	11. Functioning after electrical safety check	☐	☐	☐
12. Final cleaning	☐	☐	☐				

Notes

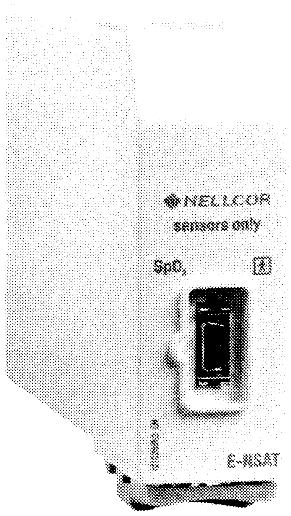
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Nellcor Compatible Saturation Module, E-NSAT (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027828
July, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda Nellcor Compatible Saturation Module, E-NSAT. The E-NSAT is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The E-NSAT module utilizes Nellcor pulse oximetry algorithm and it should only be used with Nellcor pulse oximetry sensors specified in the "Instructions for use" sheet accompanying the module.

NOTE: E-NSAT can be used with E-PRESTN/E-PRETN/E-RESTN or M-PRESTN/M-PRETN/M-RESTN or E-PSM/E-PSMP or M-NE(12)STPR/M-NE(12)STR/M-ESTPR/M-ESTR . The SpO_2 measurement in E-NSAT/M-NSAT/M-OSAT automatically overrides the SpO_2 measurement in these modules.

WARNING **To prevent erroneous readings, do not use physically damaged sensors or modules. Discard a damaged sensor immediately. Do not repair a damaged sensor or use a sensor repaired by others. A damaged sensor or a sensor soaked in liquid may cause burns during electrosurgery.**

WARNING **Inaccurate SpO_2 data can result if a sensor is past its useful life. Therefore, re-evaluate the measurement periodically by performing additional assessment of the patient and equipment, including consideration of use of alternate monitoring methods such as direct measurement of arterial oxyhemoglobin saturation (SaO_2).**

WARNING **Allow sensor and cable to dry completely after cleaning. Moisture and dirt on the connector may affect the measurement accuracy.**

WARNING **Data validity. Conditions that may cause inaccurate readings and impact alarms include interfering substances, excessive ambient light, electrical interference, ventricular septal defects (VSD), excessive motion, low perfusion, low signal strength, incorrect sensor placement, poor sensor fit, and/or movement of the sensor on the patient.**

Monitor software compatibility

The E-NSAT module functions with monitor software versions 94 or later.

1 Specifications

1.1 General specifications

Module size, (W × D ×H)	37 x 188 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	3 W
Wavelength range and energies of the light	approx. 660 nm to 890 nm

1.2 Typical performance of E-NSAT

Measurement and display range	20 to 100%
Calibration range	70 to 100%
Accuracy	70 to 100% (±1 standard deviation) ±2 to ±3.5 digits (depends on the sensor used)
Display resolution	1 digit = 1% SpO_2
Display averaging	5...7 s
Display update	5 s
Pulse beep pitch	Varies with SpO_2 level

The monitor is calibrated over the measurement range against functional saturation SpO_2 (func).

Alarm

Alarm default limits	
high alarm	OFF
low alarm	90%

Heart rate from pleth

Measurement range	20 to 300 bpm
Accuracy	±3 bpm
Resolution	1 bpm
Display averaging	5...7 s
Adjustable pulse beep volume	

Pleth waveform

Scales	Automatic scaling
Protection against electrical shock	Type BF

2 Functional description

2.1 Main components of E-NSAT

The E-NSAT module consists of the following parts

- SpO_2 pre-amplifier board
- Sensor connector cable
- Nellcor Pulse Oximeter Module MP-100
- NSAT interface board (NIO)

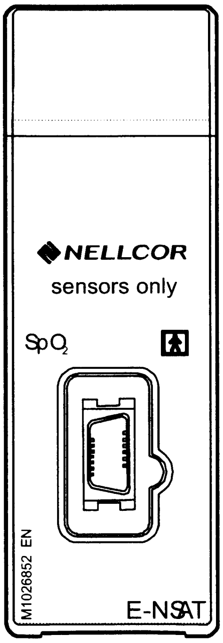


Figure 1 **Front panel of Nellcor Compatible Saturation Module, E-NSAT**

Sensors can be plugged into the E-NSAT module using the sensor extension cable DOC-10 available from Nellcor. Sensors are plugged into a 9-pin female connector (D-type) on the end of the extension cable DOC-10. The extension cable is plugged into a 14-pin connector on the front panel of the module.

The MP-100 is a surface mounted PC board manufactured by Nellcor. It contains the signal processing electronics and software that are based on Nellcor's stand-alone pulse oximeters.

The measured SpO_2 and pulse rate values, as well as status information, are transferred from the MP-100 to the NIO interface board. Communication between the MP-100 and NIO interface board is established through an RS232C serial interface. The NIO interface board, in turn, transmits the measurement information to the module bus of the monitor through RS485 serial interface.

2.1.1 NIO Interface board

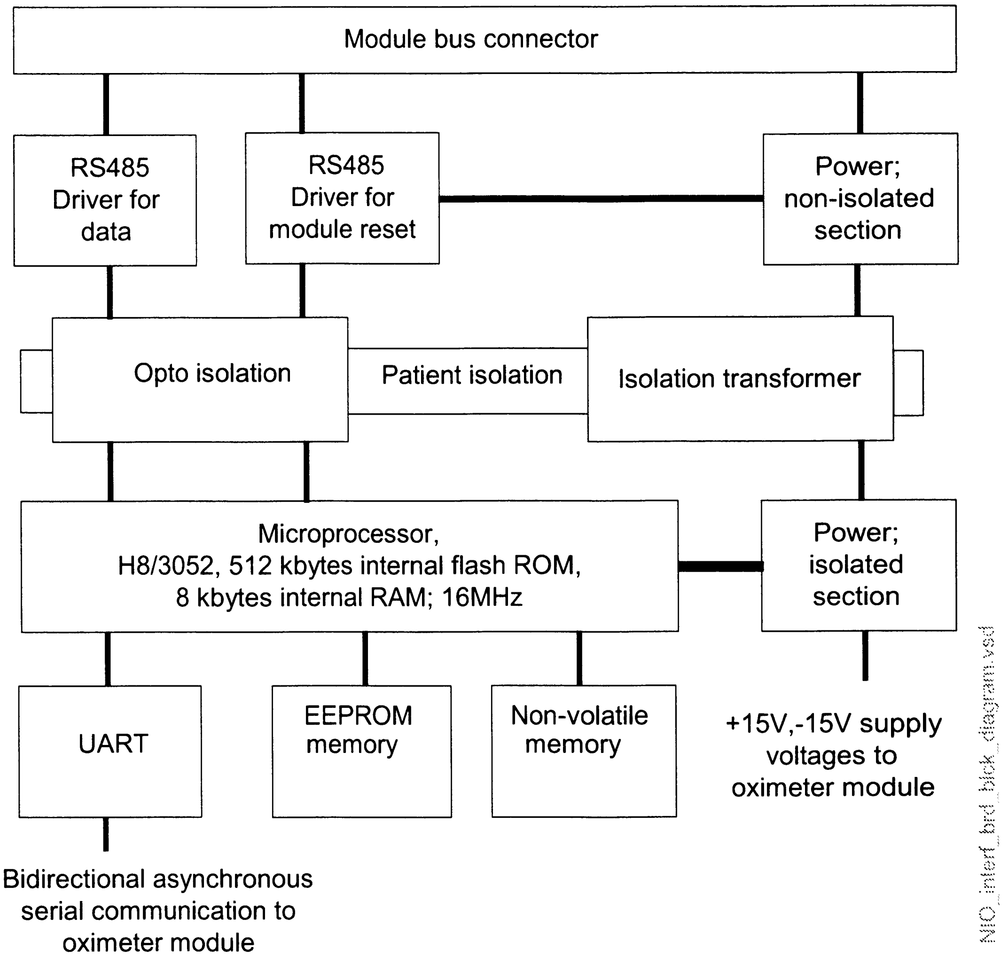

Module bus connector
RS485 Driver for data
RS485 Driver for module reset
Power; non-isolated section
Opto isolation
Patient isolation
Isolation transformer
Microprocessor, H8/3052, 512 kbytes internal flash ROM, 8 kbytes internal RAM; 16MHz
Power; isolated section
UART
EEPROM memory
Non-volatile memory
+15V,-15V supply voltages to oximeter module
Bidirectional asynchronous serial communication to oximeter module
NIO_interf_brd_blck_diagram.vsd

Figure 2 **NIO Interface board block diagram**

RS485 drivers

There are drivers for data and for module reset functions.

These drivers are used for driving the RS485 type serial communication bus between the module and the Central Unit. Data transmission speed of the bus is 500 kbps.

Power supply, non-isolated section

The power supply is a half bridge type switched mode circuit, where the driver FETs are controlled by a quartz oscillator. The load of the half bridge is the primary of the isolation transformer. The voltage, +15 Vdirty from the Central Unit is used as the supply voltage of the switched mode circuit.

Power supply, isolated section

The secondary voltages of the isolation transformer are rectified, filtered and regulated. The voltages can be measured from the test connector X11. See chapter “Other connectors”.

Opto isolation

The signals of the serial communication bus between the NIO Interface board and the Central Unit are transferred through the patient isolation by high speed opto couplers.

Microprocessor, UART, non-volatile memory

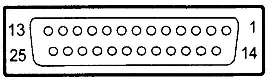
The microprocessor with on-chip memory has been used to convert and transfer data from Nellcor pulse oximeter module MP-100 to the monitor.

The communication between MP-100 and the CPU of NIO Interface board is realized with bi-directional asynchronous serial communication via the UART.

The non-volatile memory has been used to store identification information such as a serial number, control number, date, etc.

2.2 Connectors and signals

2.2.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	3	I	+15 VDIRTY
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	13	-	Ground & Shield
	15	I	GroundDIRTY
	Other	NC	Not Connected

2.2.2 Test connector (X11)

Pin No.	Voltage	Name	Note
1	+5V	+5VTEST	Supply voltage to the NSAT-board (NIO)
2	+5V	+5Vn	Supply voltage to the MP-100 board
3	+14...17V	+15Vn	Supply voltage to the MP-100 board
4	-	GND	FGND
5	--14...-17	-15V	-15Vn
6	-	-	N/C

3 Service procedures

3.1 General service information

The field service of the E-NSAT module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Another Datex-Ohmeda hemodynamic module		
Nellcor SpO_2 finger probe with DOC-10 cable		
Torx screwdriver, T10		

Detach the module box by removing the two screws from the back of the module.

3.2.2 Visual inspection

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly

- there are no loose objects inside the module
- E-NSAT ferrite of the cable sets are attached properly

✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - the probe connector and the cable lock are intact and attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1*** - ***ECG1***
Field 2 - ***ECG2***
Field 3 - ***P1***
Field 4 - ***P2***
Field 5 - ***PLETH***
Field 6 - ***OFF***

Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Installation*** - ***Interfacing*** - ***Sp02*** - ***Module***

Make sure that the other hemodynamic module is connected, and the $Sp0_2$ waveform field is shown on the screen.

Connect the finger probe to the module and attach the probe onto your finger. Check that the $Sp0_2$ waveform appears on the screen.

3. Installation

   Plug in the E-NSAT module. Check that it goes in smoothly and locks up properly.

   ✍

4. Recognition

   Check that the E-NSAT module is recognized, i.e. the $Sp0_2$ waveform with related values disappears from the screen within 30 seconds. The empty $Sp0_2$ waveform field should remain with the message 'No probe'.

   ✍

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding NSAT software by selecting ***Scroll vers*** and turning the ComWheel.

   ✍

6. Communication and memories

   Enter the E-NSAT service menu:

   Parameters - M-SAT

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check also that the module's ROM memory has passed the internal memory test, i.e. the ROM shows OK.

   ✍

7. SpO$_2$ probe status

   Check that the SpO$_2$ probe related status information in the Service Data field is correct. Only the NoProbe should be active (1) when no probe is connected.

   E-NSAT: The status information in the Service Data field is not valid for the E-NSAT. Check that the message 'No Probe' is displayed on the screen when no probe is connected.

   ✍

8. Error status

   Check that all three error indicators, Preamp Error, QUART Error and I/O Error show NO.

   ✍

9. SpO$_2$ probe detection

   Connect a SpO$_2$ finger probe to the module.

   Check that the message 'No Probe' changes to 'Check Probe' on the monitor screen.

   Check that the corresponding status information is updated correctly in the Service Data field.

   ✍

10. Test measurement

    Connect the SpO$_2$ probe onto your finger. Check that a reading of 95-100 and proper SpO$_2$ waveform appear.

    ✍

11. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

12. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

    ✍

13. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

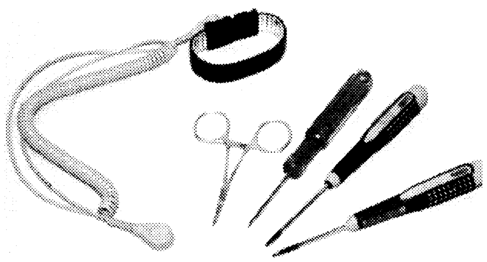
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-NSAT module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Bend the metal tabs that hold the EMC-cover to an upright position and lift the cover off.
4. Remove the three screws that secure the SpO_2 measurement board to the Interface board.
5. Hold the SpO_2 measurement board as near the module bus connector as possible and lift the board up carefully.
6. Disconnect the cable that comes from the front panel unit and the flat cable that comes from the Interface board.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps..

NOTE: When installing the SpO_2 measurement board, make sure that the pin connector on the SpO_2 measurement board connects properly with the connector on the Interface board underneath.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
'No probe' message	1. No probe connected to the module 2. Probe faulty 3. Wrong type of probe (not specified to be used with this module)	1. Check probe connections 2. Change probe 3. Change probe (see possible probe types: "User's Reference Manual")
'Check probe' message	1. No probe attached to the patient 2. The extension cable not connected to the probe 3. Unsuitable site 4. Probe faulty 5. Wrong type of probe (not specified to be used with this module)	1. See that the probe is properly attached to the patient 2. Check that the probe is connected to the cable 3. Try another place 4. Change probe 5. Change probe (see possible probe types from "User's Reference Manual")
Finger probe falls off	1. Probe is slippery 2. Finger is too thin or thick	1. For proper sensor positioning, see the "Instructions for use" accompanying each sensor. 2. Try other fingers or other probe types
Weak signal artifacts	1. Poor perfusion 2. Movement artifacts 3. Shivering	Try another place
'No pulse' message	Acceptable pulses were present but have now ceased for 10 seconds	Try other fingers

4.2 Troubleshooting flowchart

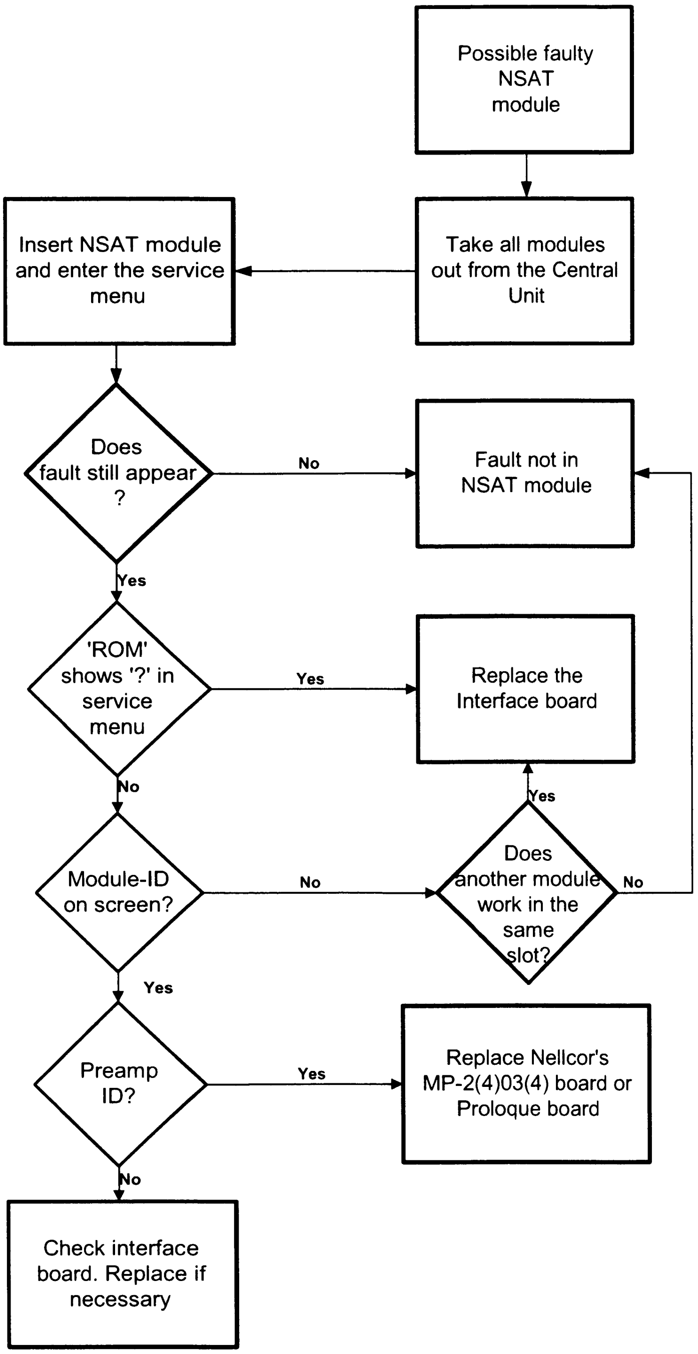

Possible faulty NSAT module
Take all modules out from the Central Unit
Insert NSAT module and enter the service menu
Does fault still appear ?
No
Fault not in NSAT module
Yes
'ROM' shows '?' in service menu
Yes
Replace the Interface board
No
Module-ID on screen?
No
Does another module work in the same slot?
Yes
No
Yes
Preamp ID?
Yes
Replace Nellcor's MP-2(4)03(4) board or Proloque board
No
Check interface board. Replace if necessary

Figure 3 **Module troubleshooting flowchart**

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} Nellcor Compatible Saturation Module, E-NSAT.

APPENDIX A Service check form, Nellcor Compatible Saturation Module, E-NSAT (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	NIO						
	Nellcor Prologue						
6. Communication and memories	☐	☐	☐	7. SpO2 probe status	☐	☐	☐
8. Error status	☐	☐	☐	9. SpO2 probe detection	☐	☐	☐
10. Test measurement	☐	☐	☐	11. Electrical safety check	☐	☐	☐
12. Functioning after electrical safety check	☐	☐	☐	13. Final cleaning	☐	☐	☐

Notes

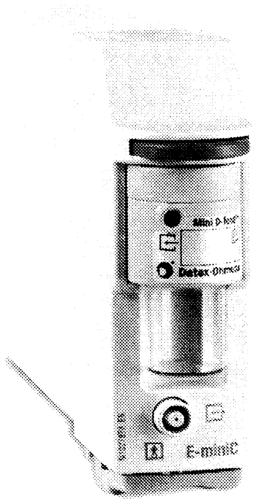
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Single-width Airway Module, E-miniC (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027829
June, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Single-width Airway Module, E-miniC. The Single-width Airway Module is a single-width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual the module may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The Single-width Airway Module provides airway and respiratory measurements.

Letter C in the module name stands for CO_2.

NOTE: Do not use identical modules in the same monitor simultaneously. The E-CO, E-COV, E-COVX, E-CAiO, E-CAiOV, E-CAiOVX, E-CAiOVX/SERVICE, E-miniC, and M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, M-CAiOVX, M-CAiOVX/SERVICE and M-miniC are considered identical modules.

NOTE: The Single-width Airway Module or Compact Airway Module and Airway Module, G-XXXX, cannot be used simultaneously in the same monitor.

NOTE: E-miniC is intended for patients weighing over 5kg (11lb).

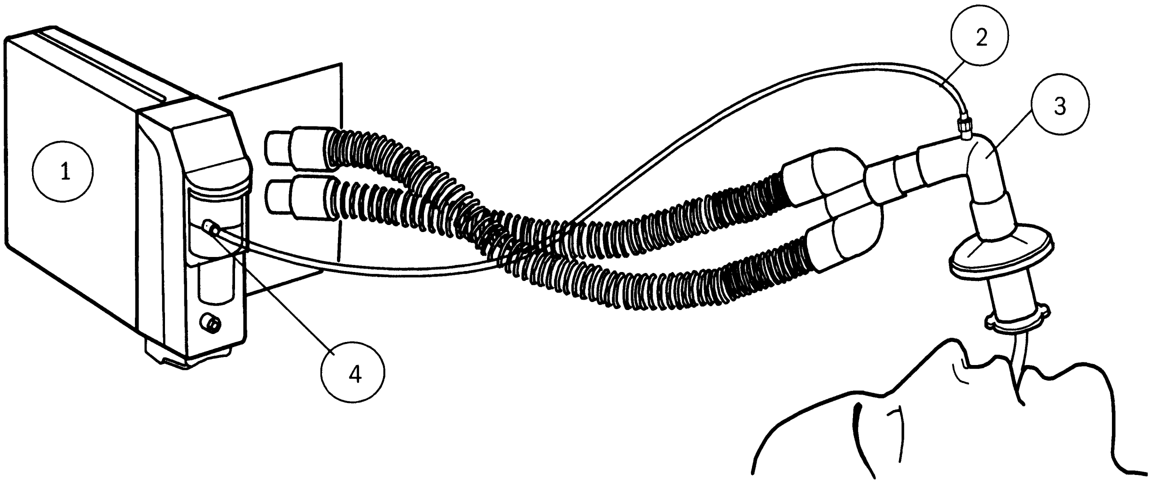


Figure 1 **Airway gases setup with Compact Airway Module**

1. Module for measuring airway gases
2. Anesthesia gas sampling line
3. Airway adapter with sampling line connector
4. Sampling line connector

Monitor software compatibility

The Single-width Airway Module, E-miniC, is designed for use with L-ANE02(A), L-ICU02(A), L-CANE02(A), L-CICU02(A) or later versions respectively.

Equipment safety symbols

⚠ - When displayed on the E-miniC module, indicates that airway gases should be calibrated every six months in normal use and every two months in continuous use.

1 Specifications

1.1 General specifications

E-MINIC

Module size, W × D× H	37 × 209 × 112 mm, 1.5 × 8.2 × 4.4 in
Module weight	0.4 kg/0.9 lb.

1.1.1 Environmental specifications

Operating temperature	+10...+40 °C (+50 to 104 °F)
Storage temperature	-20...+60 °C (-4 to +140 °F)
Atmospheric pressure	666...1060 hPa / (67...106 kPa) (500...800 mmHg) (666...1060 mbar)
Humidity	10...95% non-condensing (in airway 0...100%, condensing)
Protection against electrical shock	Type BF

1.1.2 Functional alarms

Funtional alarms for

- Blocked sample line
- D-Fend replacement
- D-Fend check

1.2 CO_2 measurement

1.2.1 Typical performance

$EtCO_2$	End-tidal CO_2 concentration
$FiCO_2$	Inspired CO_2 concentration
Measurement range	0 to 20 vol% (0 to 20 kPa, 0 to 150 mmHg)
Accuracy	CO_2 concentration 0 to 15 vol% ±(0.2 vol% +2% of reading) CO_2 concentration 15 to 20 vol% ±(0.7 vol% +2% of reading)
Measurement rise time	< 300 ms with nominal flow

Adjustable low and high limits for $EtCO_2$ and $FiCO_2$.

1.2.2 Technical specifications

Airway humidity	0...100%, condensing
Sampling rate	150 ±25ml/min (sampling line 2 to 3 m, normal conditions)
Sampling delay	2.1 seconds typical with a 3-m sampling line

Total system response time	2.4 seconds typical with a 3-m sampling line, including sampling delay and rise time (typically 3.7 seconds with a 6-m sampling line).

Automatic compensation for pressure, CO_2-NO_2 and CO_2-O_2 collision broadening effect compensation selectable from menu.

Warm-up time	1 min for operation with CO_2, 30 min for full specification
Zeroing interval	4, 15, 30 and 60 minutes after start-up, then every 60 minutes.

1.2.3 Normal conditions

Accuracy specifications apply in normal conditions (after 30 minutes warm-up period):

Ambient temperature	18...28 °C, within ±5°C of calibration
Ambient pressure	500...800mmHg, ±50mmHg of cal.
Ambient humidity	20...80% RH, ±20% RH of cal.

Automatic compensation for barometric pressure.

Non-disturbing gases are those with a maximum effect on the CO_2 reading <0.2 vol%. The effect is valid for specific concentrations shown in parentheses of the non-disturbing gas:

- Ethanol C_2H_5OH (<0.3%)
- Acetone (<0.1%)
- Methane CH_4 (0.2%)
- Nitrogen N_2
- Water vapor
- Dichloroflurομethane (<1%)
- Tetrafluoroethane (<1%)

Disturbing gases and their effect on the CO_2 reading at 5.0 vol% CO_2 are shown below. Errors listed reflect the effect of specific concentrations (shown in parentheses) of an individual disturbing gas and should be combined when estimating the effect of gas mixtures:

- Halotane (4%) increases < 0.3 vol%
- Isoflurane (5%) increases < 0.4 vol%
- Enflurane (5%) increases < 0.4 vol%
- Desflurane (24%) increases < 1.2 vol%
- Sevoflurane (6%) increases < 0.4 vol%
- Helium (50%) decreases < 0.3 vol%
- If O_2 compensation is not activated: O_2 (40 ... 95%) decreases < 0.3 vol%
- If O_2 compensation is activated: O_2 (40 ... 95%) error < 0.15 vol%
- If N_2O compensation is not activated: N_2O (40%) increases < 0.4 vol%
- N_2O (40 to 80%) increases < 0.8 vol%
- If N_2O compensation is activated: N_2O (40 to 80%) error < 0.3 vol%

1.2.4 Conditions exceeding normal

Accuracy specifications under the following conditions ❶❷❸:

❶ Ambient temperature	10...40 °C, within ±5 °C of calibration
Ambient pressure	500...800 mmHg, ±50 mmHg of calibration
Ambient humidity	10...98% RH, ±20% RH of calibration

❷ During warm-up 1 to 10 minutes, under normal conditions

❸ During warm-up 10 to 30 minutes, under normal conditions

	Accuracy under different conditions (see above)	
	Conditions ❶ and ❸	Condition ❷
CO_2 (0 ... 15 vol%)	±(0.3 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.4 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)
CO_2 (15 ... 20 vol%)	±(0.8 vol% + 4% of reading) (at 5 vol% error ±0.5 vol%)	±(0.9 vol% + 7% of reading) (at 5 vol% error ±0.75 vol%)

1.3 Respiration Rate (RR)

Measurement range	4 to 80 breaths /min
Breath detection	1% change in CO_2 level
Accuracy	±1/min in the range 4 to 20 l/min
	±5% in the range 20 to 80 l/min
Resolution	1/min

Adjustable low and high limits for respiration rate; alarm for apnea.

2 Functional description

2.1 Measurement principle

2.1.1 CO_2 measurement

MiniC is a side stream gas analyzer, measuring real time concentrations of CO_2. It is a non dispersive infrared analyzer, measuring absorption of the gas sample using an optical narrow band filter.

The infrared radiation detector is thermopile.

Concentration of CO_2 is calculated from absorption measured at 4.2 to 4.3 μm.

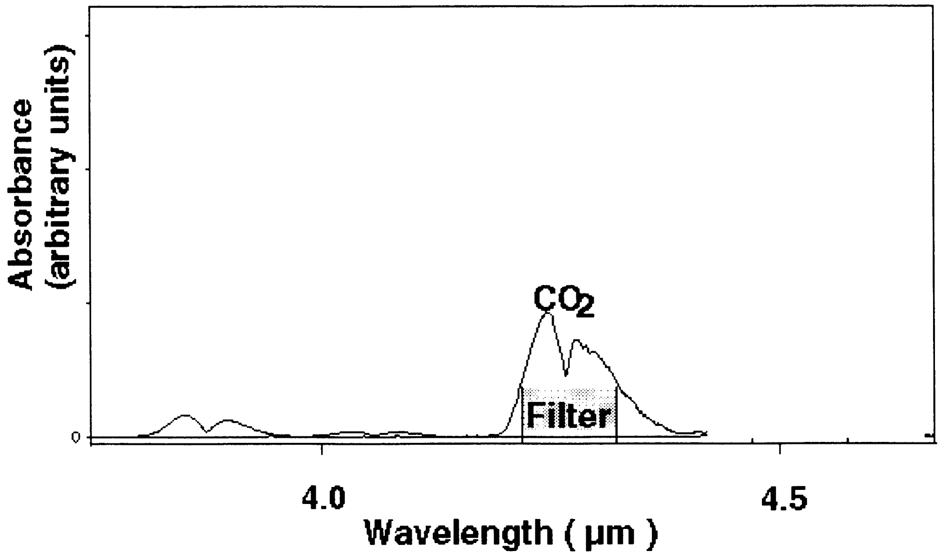


Figure 1 **Absorbance of CO_2**

2.2 Main components

- Gas sampling system
- MiniC measuring unit
- CPU board

2.2.1 Gas sampling system

The sampling system draws a gas sample to the analyzer at a fixed rate.

The gas sampling system samples the measured air to the module, and removes water and impurities from it. A sampling line is connected to the water trap. The pump draws gas through the sampling line to the gas measuring unit. After the measurement, the gas is exhausted from the sample gas out connector.

The sample flow is nominally 150 ml/min.

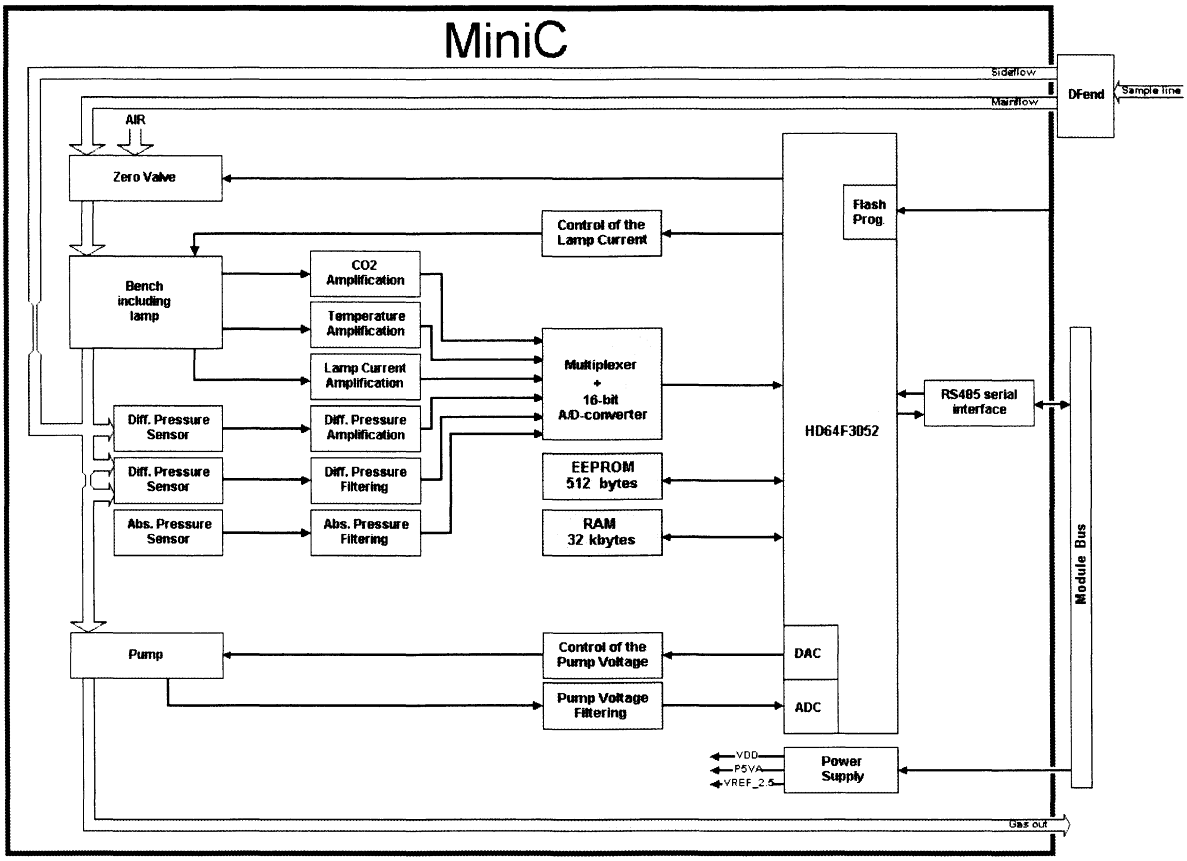

MiniC
Sideflow
Mainflow
DFend
Sample line
AIR
Zero Valve
Flash Prog
Control of the Lamp Current
Bench including lamp
CO2 Amplification
Temperature Amplification
Lamp Current Amplification
Multiplexer + 16-bit A/D-converter
RS485 serial interface
Diff. Pressure Sensor
Diff. Pressure Amplification
HD64F3052
Diff. Pressure Sensor
Diff. Pressure Filtering
EEPROM 512 bytes
Abs. Pressure Sensor
Abs. Pressure Filtering
RAM 32 kbytes
Module Bus
Pump
Control of the Pump Voltage
DAC
Pump Voltage Filtering
ADC
VDD
P5VA
VREF_2.5
Power Supply
Gas out

Figure 2 MiniC block diagram

Mini D-fend™

The sample is drawn through the sampling line. The gas then enters the module through the water trap, where it is divided into two flows, a main flow and a side flow. The main flow goes into the analyzer. This flow is separated from the patient side by a hydrophobic filter. The side flow creates a slight subatmospheric pressure within the Mini D-fend water trap which causes fluid removed by the hydrophobic filter to collect in the bottle.

Zero valve

The main flow passes through a magnetic valve before proceeding to the analyzer. This valve is activated to establish the zero point for the MiniC measuring unit. When the valve is activated, room air is drawn through a filter into the internal system and the gas sensor.

Nafion™ tube [1]

A Nafion tube is used between the water trap and the zero valve to balance the sample gas humidity with that of ambient air. The tube prevents errors caused by the effect of water vapor on gas partial pressure when humid gases are measured after calibration with dry gases.

Gas analyzers

After the zero valve and Nafion tube, the gas passes through the miniC measuring unit.

Sample flow differential pressure transducer

The sample flow differential pressure transducer measures pressure drop across a restrictor and calculates the sample flow from the pressure difference.

Working pressure transducer

The working pressure transducer measures differential pressure between the tubing and ambient air near the miniC measuring unit.

Atmospheric pressure transducer

The atmospheric pressure transducer measures real-time atmospheric pressure. The following messages are based on the obtained pressure values: 'sample line blocked', 'check D-fend', 'replace D-fend' and 'check sample gas outlet'.

Sampling pump and damping chamber

The gas sampling pump is a membrane pump run by a DC-motor. Sample flow is measured with a differential pressure transducer across a known restriction. The motor is automatically controlled to maintain a constant flow even when the D-fend water trap ages and starts to get occluded. It also enables the use of sample tubes with varying lengths and diameters.

NOTE: In no occasion is the flow reversed towards the patient.

---

1. [1] Nafion is a trademark of Perma Pure Inc.

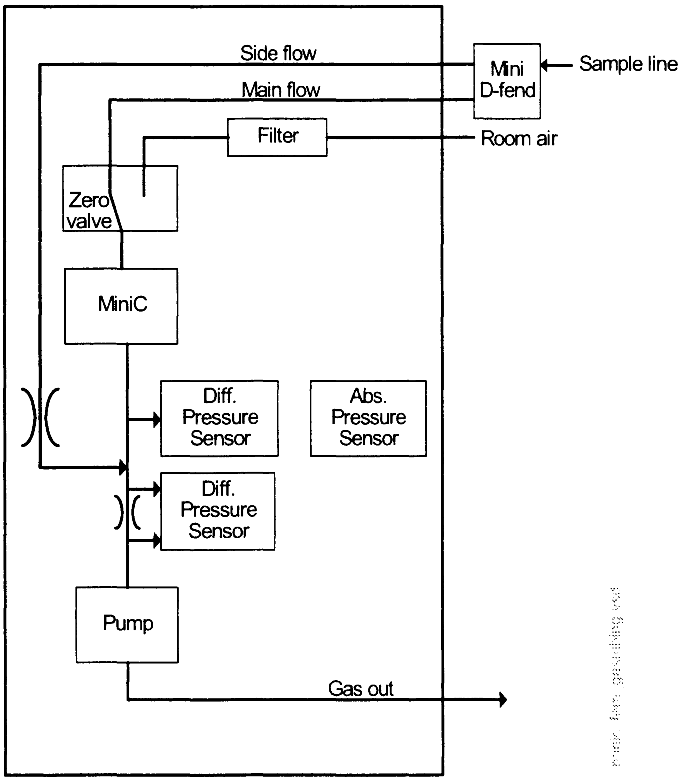

Side flow
Main flow
Mini D-fend
Sample line
Filter
Room air
Zero valve
MiniC
Diff. Pressure Sensor
Abs. Pressure Sensor
Diff. Pressure Sensor
Pump
Gas out

Figure 3 **Gas tubing layout**

2.2.2 MiniC measuring unit

The miniC measuring unit is a non-dispersive infrared analyzer measuring absorption of the gas sample at 4.2 to 4.3 μm infrared wavelength, which is selected using an optical narrow band filter. The IR lamp is a filament surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length. From the sample chamber, the radiation goes into a thermopile detector with an optical filter in front of it.

The temperature sensor measures the miniC measuring unit's temperature and it is used for temperature compensation.

The miniC measuring unit includes a miniC flexible board, which connects the thermopile signal and the temperature sensor signal to the CPU board.

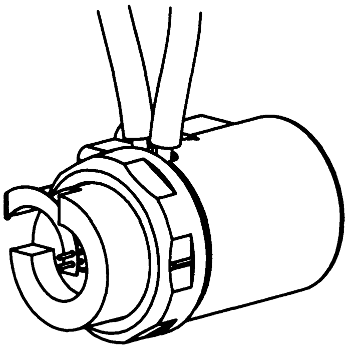


Figure 4 **MiniC measuring unit**

2.2.3 CPU board

The CPU board contains a processor, memories and all the analog signal processing needed. A MiniC measuring unit is attached to the board with a flexible PCB. Also supply voltage and an RS485 serial channel are connected to the CPU board using another flexible PCB.

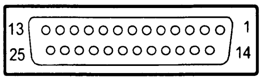
Analog signals (CO_2, temperature, absolute and differential pressures and lamp current signals) are fed to the 16-bit A/D converter. The processor controls the A/D converter and calculates the CO_2 percentage and respiration rate from this data.

The processor controls sample flow by adjusting the pump voltage based on the differential pressure signal. The processor also controls the current of the IR source and keeps it constant.

Calibration data is stored on the EEPROM.

2.3 Connectors and signals

Table 1 Module bus connector pin description

Module bus connector	Pin No.	I/O	Signal
	1	I	RESET RS485
	2	I	-15 VDC (not used)
	3	I	+15 VDIRTY
	4	I	+15VDC (not used)
	5	I/O	-DATA RS485
	6	I/O	DATA RS485
	7		Ground and Shield
	8	I	-RESET RS485
	9		n/c
	10		n/c
	11		n/c
	12		n/c
	13		Ground and Shield
	14	I	+24/+32 VDIRTY depends on power supply (not used)
	15	I	Ground DIRTY
	16		n/c
	17		n/c
	18		n/c
	19		n/c
	20	I	GASFR (not used)
	21	I	CTSD (not used)
	22	I	TXDD (not used)
	23	O	RXDD (not used)
	24	I	+5 VDC (not used)
	25	I	+5 VDC DIRTY (not used)

3 Service procedures

3.1 General service information

The field service of the E-miniC module is limited to replacing parts that are available as spare parts. For available spare parts, refer to the “E-Modules Spare Parts” slot.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

3.1.1 MiniC measuring unit

WARNING **The miniC measuring unit and its components are repaired/calibrated at the factory. Attempts to repair/calibrate the unit elsewhere will adversely affect operation of the unit. The information provided is for reference only.**

Serviceable parts

- Mini D-fend
- Mini D-fend O-rings
- Nafion tube
- Air filter
- Pump

NOTE: After any component replacement, see chapter “Adjustments and calibrations”.

Calibration interval six months. Preventive maintenance once a year including the change of Nafion tube and the O-rings of water separator, pump check and calibration, leak test and absolute pressure sensor check.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form (“APPENDIX A”) which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Screwdriver		Pozi-drive, Torx T10
Ambient pressure manometer		Amb. Press. can be checked from local meteorological station
Flowmeter		TSI model 4140 recommended
Flow cassette 50/1.1	873812	
Calibration gas and the regulator	755580 (gas) 755534	Contains 5 CO2 and air
Gas Interface Cable	884299	
Patient simulator		

3.2.2 Recommended parts

Parts	Order No.	Notes
Mini D-Fend	8002174	Pkg of 10 pieces
Sampling line 3m / 10 ft	73319	Pkg of 10 pieces
Mini D-fend O-ring (2 pcs)	656565	
Nafion tube	733382	

3.2.3 Inspection

General

1. Check internal parts
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly
   - there are no loose objects inside the module

2. Check external parts
   - the front cover and the front panel stickers are intact
   - the Mini D-fend latch is moving properly
   - all connectors are intact and attached properly

Reattach the module and check that the locking system moves properly.

3. Check Mini D-Fend

   Detach the Mini D-fend. Check the condition of the rubber O-rings on the metal Mini D-fend connectors, located in the module front cover.

   If necessary, detach the connectors by first disconnecting the tubes, then removing the locking rings from the back of the front cover.

   ✍

   Replace the Mini D-fend and sampling line with new ones.

NOTE: Use only Datex-Ohmeda sampling lines in order to ensure proper functioning.

Turn on the monitor.

Configure the monitor screen so that the CO_2 curve is shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform fields*** -
Field 6 - CO2
Digit Fields
Lower Field 1 - Gases

4. Module software

   Wait until the message 'Calibrating gas sensor' disappears from the screen, then enter the service menu.

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8).

   Write down the information regarding the Module software.

   If one of the values is increasing faster, it indicates a failure in module bus communication.

   ✍

5. Flow measurement offset

   Enter the service menu ***Gases***:

   Gas Unit - Gases

   Check that the flow measurement offset, i.e. the shown sample Zero value is within ±10 ml/min.

   ✍

6. Ambient pressure

   Check that the shown Ambient value corresponds with the current ambient pressure (±20 mmHg).

   ✍

7. Zero valve check

   Feed calibration gas and check that the gas readings in the service menu correspond with the values on the gas bottle sticker. Keep feeding gas, then activate the zero valve from the menu. The CO_2 reading should drop back to near 0%.

   ✍

8. Nafion tube

   Replace the Nafion tube, if necessary.

NOTE: The Nafion tube should be replaced annually.

   ✍

9. Leak test

   Perform the sampling system leak test.

   Connect a flow cassette with high flow resistance value (50/1.1) to the end of the sampling line and start following the Amb-Work value in the service menu. When the value exceeds 130 mmHg, connect the other port of the flow cassette to the sample gas out connector and switch off the pump.

   Wait until the pressure inside the sampling system is stabilized, then observe the shown Amb-Work value. The value, i.e. the pressure inside the sampling system should not drop more than 6 mmHg in 20 seconds.

   If the pressure drops more, first check the connections and repeat the test.

   ✍

10. Check the flow rates

    Wait until the Sample Flow value returns close to 150 ml/min.

    Connect a flow meter to the 3 meter sampling line and check that the flow (the flow meter reading) is within the following range:

    Sampling flow (ml/min) 135...165

    If necessary, readjust the sampling flow:

    Select ***Sample gain adj*** from the menu.

    To increase the sampling flow, turn the ComWheel counterclockwise. To decrease the flow, turn the ComWheel clockwise.

    A change of 0.050 in the Gain value changes the flow approximately 7.5 ml/min.

    After you have changed the gain, wait until the Sample Flow value on the screen returns near to the original, then check the flow meter reading again.

    ✍

11. Working pressure

    Check that the Amb-Work value in the service menu is within the following range:

Amb-Work (mmHg) 20...50

✍

12. Gas calibration

    Airway Gas - ***Gas Calibration***

NOTE: The calibration should not be performed before 30 minutes warm-up time.
Use calibration gas 755580 (5% CO_2, about 20% O_2) for calibrating the E-miniC.

✍

13. Occlusion detection

    Block the tip of the sampling line with your finger and check that the message 'Sample line blocked' appears on the monitor screen within 60 seconds.

✍

14. Check D-fend

    Detach the mini D-fend and check that the message 'Check D-fend' appears on the monitor screen within 30 seconds.

✍

15. Apnea detection

    Reattach the mini D-fend. Simulate at least 5 breaths by feeding calibration gas into the sampling line. Check that the shown gas information is correct.

    Check that the monitor shows the message 'Apnea' within 30 seconds after you have stopped feeding the gas.

✍

16. Final cleaning

    Turn off the monitor, disconnect and clean the module.

✍

- Fill in all necessary documents.

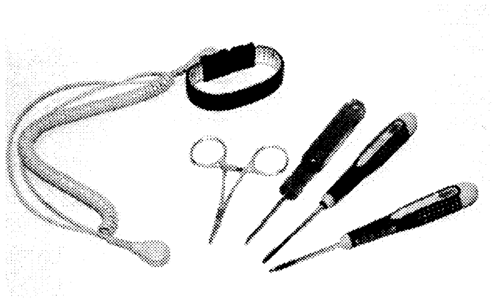
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdrivers; T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the airway module (see the exploded view of the module in the “E-Modules Spare parts” slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

3.4.1 Pump unit

1. Remove the module cover.
2. Remove the mask.
3. Unplug the hose of the pump.
4. Disconnect the pump’s cable from the CPU board.
5. Remove the three screws that connect the pump unit to the board.

To reassemble the module, reverse the order of the dissassembly steps.

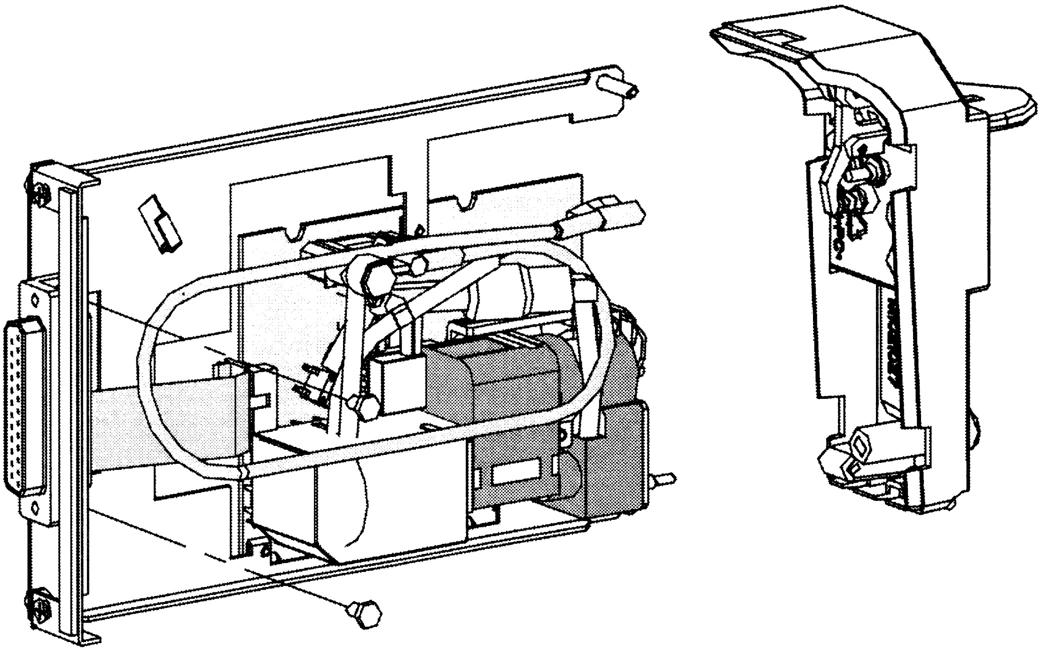


Figure 5 **Uncovered E-miniC module**

3.4.2 MiniCO$_2$ assy

1. Remove the module cover.
2. Unplug two tubes from the back of the mask.
3. Remove the mask.
4. Detach the miniCO$_2$ assy from the frame plate by removing the three screws.
5. Disconnect the FM board from the miniCO$_2$ assy.

To reassemble the module, reverse the order of the dissassembly steps.

3.4.3 Instructions after replacing MiniCO$_2$ assy

After replacing the MiniCO$_2$ assy:

- perform the sampling system leak test
- perform the occlusion test
- perform the gas calibration

3.5 Adjustments and calibrations

3.5.1 Calibrating

NOTE: Ensure that the calibration gas and regulator are functioning properly before calibration. Perform the annual maintenance of the regulator as required.

The airway module should be calibrated once every six months or whenever there are indications of errors in the gas readings.

Calibrate the gas measurement with the Datex-Ohmeda calibration gas. Do not use any other calibration gases.

- Use the regulator 755534.

When you calibrate the E-miniC module, use gas 755580 only and set the O2 concentration to 20%.

Use only recommended calibration gases to guarantee a successful calibration.

During gas calibration, % units are always used for CO_2 regardless of selected measuring units.

NOTE: Ensure that the calibration gas and regulator are functioning properly before calibration. Perform the annual maintenance on the regulator as required.

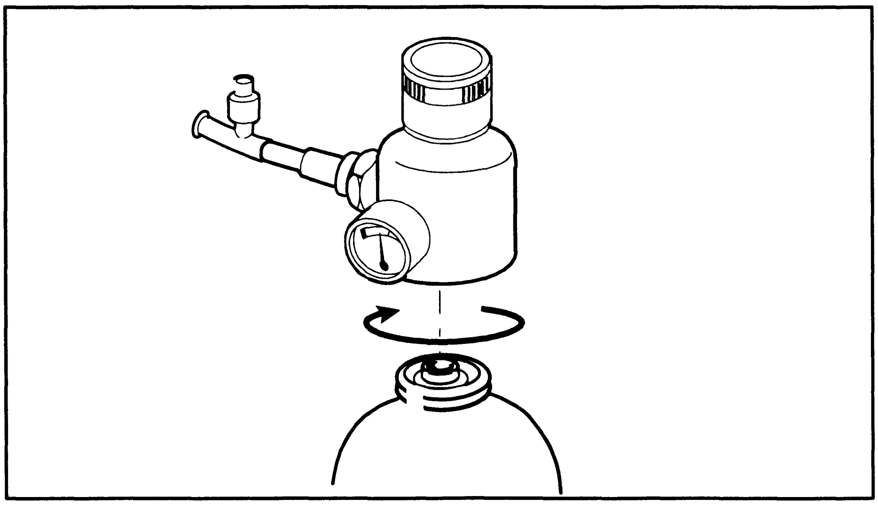


Figure 6 Attaching regulator to the calibration can

1. Attach the regulator to the gas container.
2. Attach a new sampling line to the water trap. Connect the loose end of the sampling line to the regulator on the gas container.

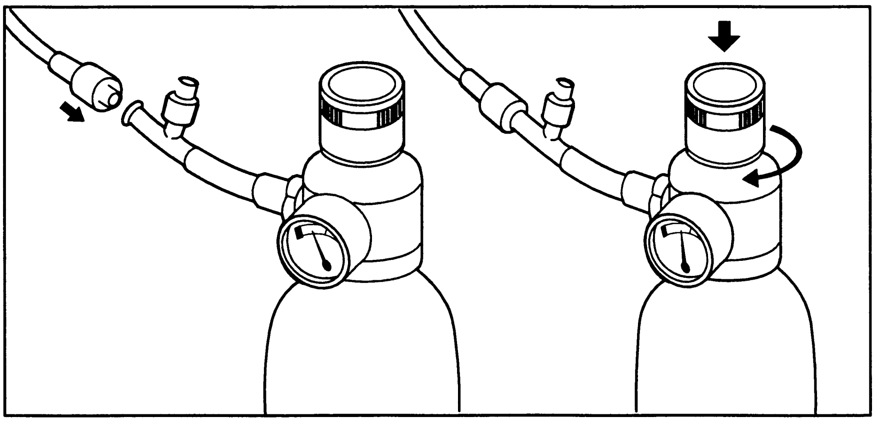


Figure 7 Connecting sampling line to the gas valve and feeding gas

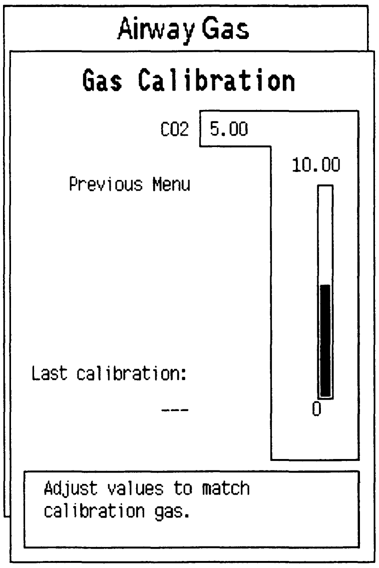
3. Turn on the power. For maximum accuracy, let the monitor warm up for 30 minutes. The menu item ***Gas calibration*** remains gray as long as the message 'Calibrating gas sensor' is displayed.
4. Press the **Airway Gas** key and select ***Gas calibration***.
5. Wait until the 'Zero ok' and then the 'Feed gas' messages appear after each gas on the screen.
6. Open the regulator and feed calibration gas until the message 'Adjust' appears, then close the valve. If you use an older brass regulator, the feeding pressure should be adjusted between 5 and 7 psi.
7. Check that the displayed gas value matches the value on the calibration gas container.

NOTE: When calibrating the E-miniC module, set the 0_2 level according to the gas, for example with 755580, set the $Fi0_2$ level in the C02 setup menu to 21-40% and the ***AIRWAY GAS - CO2 SETUP*** 0_2 level to 20%. Adjust the 0_2 percentage according to the calibration gas (for 755580 the right 02 value is 20%).

NOTE: If an error occurs during calibration or if no gas is fed, the highlighting goes automatically over the item ***Recalibrate*** and the text 'Calibr. error' appears. Push the ComWheel to perform a new calibration.

If adjustments are required:

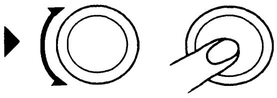
- Turn the ComWheel to highlight the first gas to be adjusted and then push the ComWheel.
- Turn the ComWheel until the displayed value matches the desired value in the gas bottle and push it again.



CO2 5.00

Last calibration:

Adjust values to match calibration gas.



If the message 'Zero error' is displayed, press the **Normal Screen** key and repeat the calibration procedure.

The time of the last calibration is shown at the bottom of the menu page.

3.5.2 Gas sampling system adjustment

For flow rate measurements, a flow meter with a low flow resistance and the capability to measure low flow rates is required. A sampling line of normal length has to be connected to the monitor as it has a considerable effect on the flow.

3.5.3 Flow rate measurement

If any flow rates are not correct, first replace the Mini D-Fend water trap, then recheck the flows.

The sampling flow rate is measured by a flow meter at the sampling line. The flow rate should be between 135 and 165 ml/min. The flow rate is adjusted in the ***Gases*** service menu with ***Sample gain adj***.

3.5.4 Flow rate adjustment

NOTE: Before adjusting the sampling flow, make sure there is no leakage in the sampling system.

Refer to chapter *3.2 Service check,* step 12. Gas calibration.

Wait until the Sample Flow value is back to near 150 ml/min.

Connect a flow meter to the 3 meter sampling line and check that the flow (the flow meter reading) is within the following range:

Sampling flow (ml/min)	135...165

If necessary, readjust the sampling flow:

Select ***Sample gain adj*** from the menu.

To increase the sampling flow, turn the ComWheel counterclockwise.

To decrease the flow, turn the ComWheel clockwise.

A change of 0.050 in the Gain value changes the flow approximately 7.5 ml/min.

After you have changed the gain, wait until the Sample Flow value on the screen returns near to the original, then check the flow meter reading again.

3.5.5 Gas calibration

Gas calibration is performed in the ***Airway Gas*** menu.

Calibration gas regulator flow check

Interval: every 12 months

Regulator flow specification:

REF 755533 & 755534: 260 - 410 ml/min at 1-10 bar cylinder pressure
REF 755530: 260 - 410ml/min at 5-7psi cylinder pressure

Tools needed: calibration gas can, regulator, piece of silicon hose and flow meter. GE Healthcare recommends use of TSI 4140 Flow Meter.

Insert the calibration gas regulator on the gas cylinder. Connect a silicon hose between the regulator and the flow meter. Block the regulator overflow port and open the regulator. Check the flow rate from the flow meter and verify that the flow is within the specification.

4 Troubleshooting

4.1 Troubleshooting chart for CO_2 measurement

Problem	**Cause/What to do**
No response to breathing	Sampling line or water trap blocked or loose, or improperly attached. Water trap container full. See the gas sampling system troubleshooting.
'SENSOR INOP.' message	The temperature is too low or high, check the temperature in the service menu. Supply voltage is too low or high, IR source current or voltage is too low or high, check current in the service menu. Pump is not working properly, check sample flow and pump voltage in the service menu. Ambient pressure too low or high, check the ambient pressure in the service menu. Zero valve not working properly, check the functionality by switching zero valve on and off in the service menu.
'ZEROING ERROR' message	Gas zeroing failed. Condensation or residual gases are affecting the zero measurement. Allow the module to run drawing room air for half an hour and calibrate again.
'CHECK D-FEND' message	Amb - Work pressure difference too small. Probably water trap or the sampling line is not attached properly. Gas zero valve failure. Pump failure or gas outlet blockage.
'REPLACE D-FEND' message	Amb - Work pressure difference too big. Indicates residue build-up on the water trap membrane. This decreases air flow. Replace the D-fend.
'SAMPLE LINE BLOCKED' message	Amb - Work pressure difference too big. Sampling line or water trap is occluded. Water trap container is full. If occlusion persists, check internal tubing for blockages.
No response to any gas	Check Sample Gas Out. Amb - Work pressure low, flow too small and pump voltage too high. Sampling line, water trap, or internal tubing is blocked or loose, or improperly attached. Gas out connector or tubing is blocked. Zero valve malfunction. Pump failure or pump is worn. Supply voltage missing. Serial communication error.
Sudden increase in gas display	Water trap malfunction. Check all internal tubing and the interior of the water trap for occlusions or leaks. Replace water trap. Check flow rates.
Abnormally high (or abnormally low) response to CO_2 or sudden occlusion warning	Pressure transducer failure. Check the Ambient and Amb - Work pressures in ***Gases*** service menu.
Strong drift in all gases	Leak in sampling line or internal tubing (especially in conjunction with too low readings).

4.1.1 CO_2 measurement

Problem	**Cause**	**What to do**
Action too low $ETCO_2$ value	• sudden decrease in circulation • pulmonary embolism • hyperventilation • very large dead-space • large shunting • leak in sampling system • calibration error • high by-pass flow from ventilator	• check all connections • check calibration
too high $ETCO_2$	• hypoventilation • increased metabolism • D-fend contaminated • calibration error	• change D-fend • check calibration
waveform clipped	• incorrect scaling	• change scale
no response to breathing	• apnea • (disconnection)[1)] • sampling line or water trap loose or blocked (air leak)[1)]	• check all connections
	• sample gas outlet blocked	• check that outlet is open
$ETCO_2$ over scale >20% Shown until 32%, specified range 0...20%	• abnormally high $ETCO_2$ (permissive hypercapnia) • CO_2 sensor contaminated • D-fend malfunction	• let the module run without a sampling line until the CO_2 sensor has dried out • change D-fend
$ETCO_2$>$PaCO_2$	• unit is mmHg or kPa and $ETCO_2$ is close to arterial PCO_2 • "dry gas" as default	• change to "wet gas" by using install/service menu

4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, failure of the sampling pump or the magnetic valves, or diminishing of the flow rates because of dirt accumulating in the internal tubing.

The following checks should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and if necessary adjust the flow rate.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

NOTE: D-fend water trap should be replaced, when the 'REPLACE D-FEND' message appears during the monitor startup.

NOTE: If any liquid has entered the miniC measuring unit due to water trap filter failure, leave the module running without a sampling line for several hours and check the functions after it has dried out.

4.2.1 Sampling system leak test

1. Connect a flow cassette with a high flow resistance value (50/1.1) to the end of the sampling line and start following the 'Amb-Work' value in the service menu. When the value exceeds 130 mmHg, connect the other port of the flow cassette to the sample gas out connector and switch off the pump.
2. Wait until the pressure inside the sampling system is stabilized, then observe the shown Amb-Work value. The value, i.e. the pressure inside the sampling system, should not drop more than 6 mmHg in 20 seconds.
3. If the pressure drops more, first ensure the connections you have made and repeat the test.

4.3 MiniC unit troubleshooting

CAUTION The miniC measuring sensor can only be repaired and calibrated at the factory. In case of failure, the complete miniC unit should be sent to GE Healthcare for factory exchange.

4.4 Error messages

Message	Explanation
Occlusion or Sample Line Blocked	The sample tube inside or outside the monitor is blocked or water trap is occluded. If occlusion persists, measured gas values disappear.
Continuous occlusion. Check sample line and D-fend.	Occlusion over 40 seconds.
Check D-fend	- The water trap is not connected - There is a leak in the sampling line inside the module. If air leak persists, measured gas values disappear. Check sample gas out.
(Air leak detected.) Check water trap and sample gas out-flow. Press normal screen to continue.	Air leak over 40 seconds.
Replace D-fend (replace water trap)	Indicates residue build-up on the water trap membrane. This decreases air flow.
Gas calibration is not available during first 5 minutes/during occlusion/during air leak	Entering calibration is not allowed during 5 minutes after power up and during occlusion or air leak.

Message	**Explanation**
Gas out blocked	- Gas out connector on the front panel, or the exhaust line connected to it, is blocked. - If the sample gas is returned to the patient circuit, the filter in the return kit may be occluded. - Make sure the sample gas outlet is connected to an open scavenging system only where gas is removed in room pressure.
Recalibration	Time out, fluctuating gases, gain adjusted “over”.
Zero error	Unsuccessful zeroing.
Unstable, Calibr error	Unsuccessful calibration.
Menu messages during calibration:	
Zero error	Unsuccessful zeroing.
Adjust	Calibration gas accepted and monitor is ready for adjusting the gas values to match the calibration gas concentration.
Unstable	Unsuccessful calibration.

APPENDIX A Service check form, Single-width Airway Module E-miniC (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

General	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
1. Check internal parts	☐	☐	☐	2. Check external parts	☐	☐	☐
Notes							
CO_2 measurement							
3. Check Mini D-Fend	☐	☐	☐				
4. Module software	GAS						
5. Flow measurement offset					±10 ml/min		
6. Ambient pressure	☐	☐	☐	7. Zero valve check	☐	☐	☐
8. Nafion tube	☐	☐	☐				
9. Leak test					≤6 mmHg/20 sec		
10. Check the flow rates							
Sampling flow					135...165 ml/min		
11. Working pressure							
Amb-Work					20...50 mmHg		
12. Gas calibration	☐	☐	☐	13. Occlusion detection	☐	☐	☐
14. Check D-fend	☐	☐	☐	15. Apnea detection	☐	☐	☐
Notes							

General	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
16. Final cleaning	☐	☐	☐				

Notes

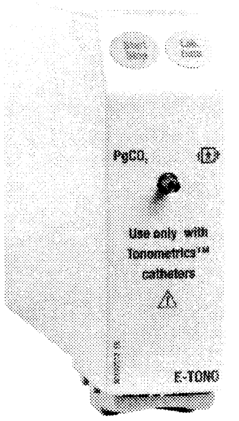
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Tonometry Module, E-TONO (Rev. 00)

Technical Reference Manual



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027830
June, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Tonometry Module, E-TONO. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The S/5 Tonometry Module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. The module provides gastric tonometry measurement, i.e. it measures the gastrointestinal CO_2 concentration, $PgCO_2$.

The Tonometry Module contains the CO_2 gas concentration sensor and a gas sampling system to move gas between the patient's gastrointestinal tract and the sensors. The patient is connected to the module with a Tonometrics™ Catheter, which is inserted into the gastrointestinal tract.

A sample is taken at regular intervals to determine the CO_2 concentration of the gas.

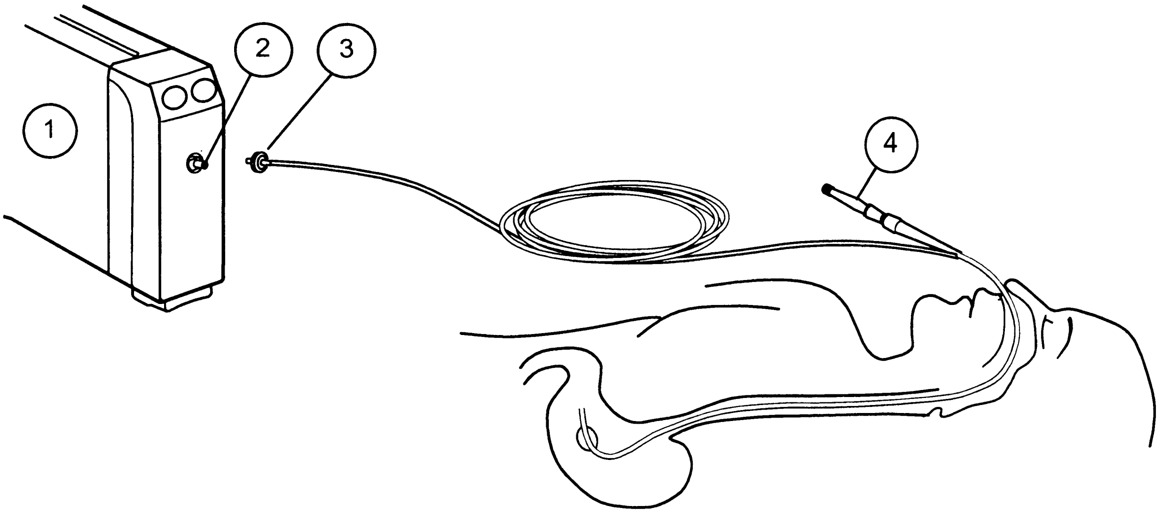


Figure 1 Patient connections

(1) Tonometry Module, E-TONO
(2) Catheter connector
(3) Biofilter
(4) Tonometrics catheter

Monitor software compatibility

The S/5 Tonometry Module, E-TONO, functions only with monitor software of level 99 or later.

Equipment safety symbols

⚠	- When displayed on the E-TONO module, indicates that the module should be used only with Tonometrics catheters.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 × 193 × 112 mm, 1.5 × 7.6 × 4.4 in
Module weight	0.55 kg / 1.2 lbs.
Operating temperature	+10...+40 °C
Storage temperature	-25...+70 °C
Atmospheric pressure	666...1060 hPa (67...106 kPa/500...800 mmHg/666...1060 mbar)
Humidity	10...90% RH non-condensing
Power consumption	0.7 W Prms, 9.0 W momentary
Protection against electrical shock	type BF (IEC-60601-1) defibrillator-proof protection against electric shock

1.2 Parameter specifications

Measurement interval is 10 minutes.

1.2.1 PgCO$_2$

Measurement range	0...30 kPa (0...228 mmHg)
Accuracy[1]	
in range 0...15 kPa (0...113 mmHg)	±(0.5 kPa +5% of reading) ±(4 mmHg +5% of reading)
in range 15...30 kPa (113...228 mmHg)	±(1.5 kPa ±15% of reading) ±(12 mmHg ±15% of reading)

NOTE: Accuracy specifications apply in normal conditions:

- Measurement is done at least 30 minutes after catheter initialization
- Calibration has been checked within 2 weeks.
- Ambient temperature: 10...40 °C, within ±5 °C of calibration
- Ambient pressure: 500...800 mmHg, ±50 mmHg of calibration
- Ambient humidity: 10...90% RH, ±20% RH of calibration

---

[1] These specifications only apply when TONO-8F, TONO-14F, TONO-16F, TONO-18F catheters with 13 mm biofilter are used.

2 Functional description

2.1 Measurement principle

2.1.1 CO_2 measurement

The CO_2 sensor measurement is based on the infrared (IR) absorption technique. CO_2 molecules absorb IR-light that has a certain wave length (4.26 μm). This wavelength is selected from the incoming IR-light with a special optical bandpass filter. The IR-light passed through the measurement chamber and the filter, and the signal is then detected with a thermopile.

The calculation of CO_2 concentration needs also the determination of the signal level, when there is no CO_2 in the measured gas. This procedure is the zeroing of the sensor. The zeroing is done with room air and it is always performed before measuring the sample gas.

The CO_2 and zeroing gas measurements are performed by pulsing the IR-lamp 3 times (lamp is on for 2 seconds and off for 2 seconds) and by measuring the thermopile signal during pulsing. The CO_2 concentration is defined then from these signals. In the definition of CO_2 partial pressure ($PgCO_2$), the influence of sensor temperature, measurement pressure, catheter pressure, gas mixing in tubings and the drop in water vapor pressure on the measurement result are compensated.

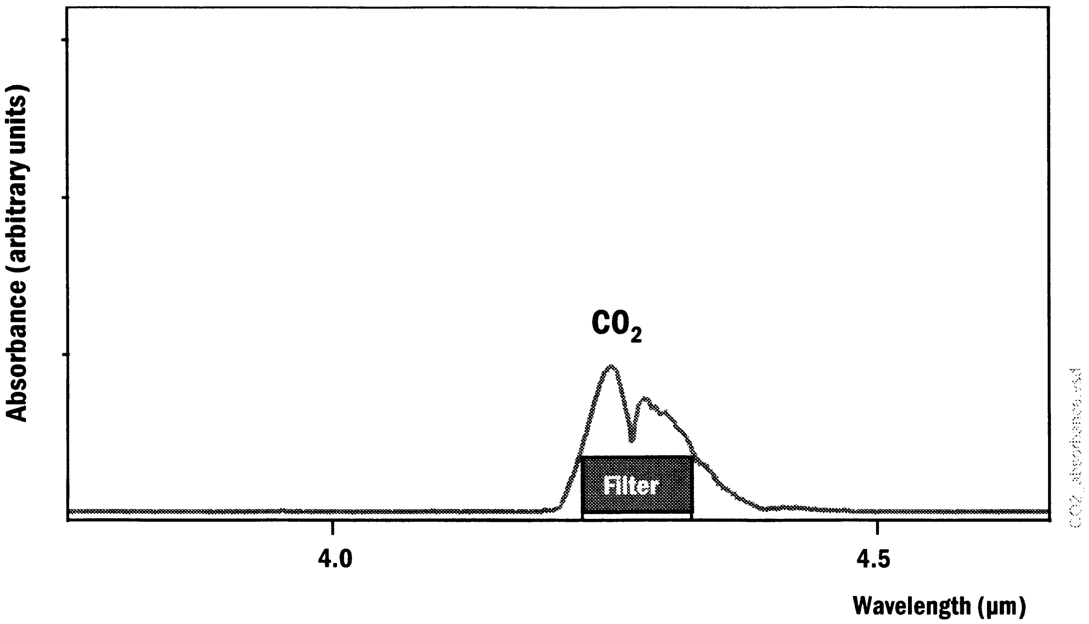
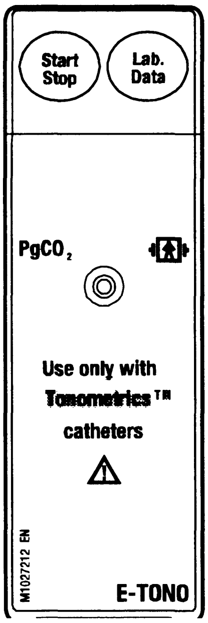


Figure 2 Absorbance of CO_2

2.2 Main components


Start
Stop
Lab.
Data
PgCO₂
Use only with
Tonometrics™
catheters
M1027212 EN
E-TONO

Start Stop	Starts/Stops the $PgCO_2$ measurement cycle.
Lab. Data	Takes you to Lab Data menu to enter the blood gas values.

Figure 3 Front panel of Tonometry Module, E-TONO

The tonometry module consists of:

- gas sampling system
- CO_2 measuring unit
- CPU board.

2.2.1 Gas sampling system

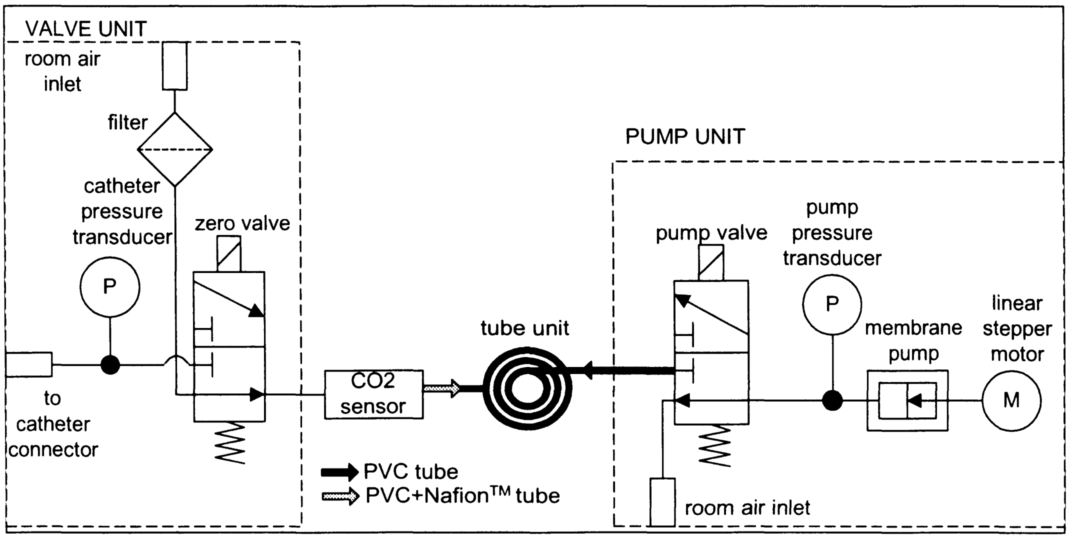

VALVE UNIT
room air inlet
filter
catheter pressure transducer
zero valve
P
to catheter connector
CO2 sensor
tube unit
PVC tube
PVC+Nafion™ tube
PUMP UNIT
pump valve
pump pressure transducer
P
membrane pump
linear stepper motor
M
room air inlet

Figure 4 Gas sampling system layout

The tonometry measurement is done at regular intervals of 10 minutes. The measurement cycle starts with CO_2 sensor zeroing. Zeroing means flushing the gas measurement chamber with room air and measuring the signal level of IR-light passed through the room air. Right after zeroing the sensor, sample gas is aspirated from the tonometry catheter and the IR-signal passed through the sample gas is measured. The actual CO_2 concentration is determined from the measured zero signal and the CO_2 signal. After determining the catheter gas CO_2, the system ensures the catheter is emptied by creating a vacuum to empty any residual gas. After generating the vacuum, the tubing system is equilibrated close to the ambient pressure by switching the pump valve on and off. Thus, the catheter is always filled with the same amount of gas. The catheter is refilled with measured sample gas.

Catheter pressure transducer

The catheter pressure transducer measures absolute catheter pressure.

Zero valve

The valve is normally open to room air. When sample gas is measured from the catheter, the zero valve becomes active.

Sensor

After the zero valve, the gas passes through the CO_2 sensor.

Nafion™ tube 1)

A Nafion tube is used between the CO_2 sensor and tube unit to balance the sample gas humidity with that of ambient air. The CO_2 sensor measures humid gas and Nafion tube prevents humidity from increasing in the tubes.

Tube unit

The tube unit is used between the Nafion tube and pump unit to store the sample gas.

Pump valve

The valve is normally open to room air. When CO_2 concentration is measured from the sample gas or from room air, the pump valve becomes active.

Pump pressure transducer

The working pressure transducer measures absolute pump pressure. It is used for the 'Catheter empty' message, 'Catheter leakage' message and 'Unable to fill' catheter message.

Membrane pump and linear stepper motor

The gas sampling pump is a membrane pump that is run by a linear stepper motor. Sample volume is 4 ml.

---

1. 1) Nafion is a trademark of Perma Pure Inc.

2.2.2 CO_2 sensor

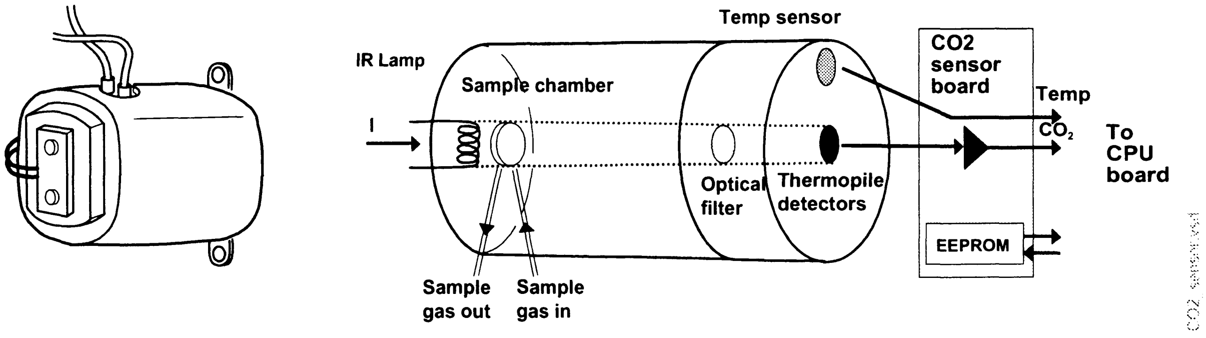

Temp sensor
IR Lamp
Sample chamber
I
Optical filter
Thermopile detectors
Sample gas out
Sample gas in
CO2 sensor board
Temp
CO2
To CPU board
EEPROM

Figure 5 CO_2 sensor

The CO_2 sensor is a non dispersive infrared analyzer, measuring absorption of the gas sample at CO_2 infrared wavelength, which is selected using an optical narrow band filter. The IR lamp is a 500 mW filament, surrounded by thermal isolation. There is a hole in the isolation, passing the radiation to a conical measuring chamber with 3 mm length.

The CO_2 sensor contains an own preamplifier board, which amplifies the thermopile signal. The preamplifier board also contains EEPROMs that store calibration data of the CO_2 sensor.

The Temp sensor measures the temperature of the CO_2 unit and it is used for temperature compensation.

CPU board

The CPU board contains the processor, memories and AD-converter that are common to the whole module. The CPU board also contains preamplifiers of pressure sensors and drivers for valves, a linear stepper motor and a lamp. The module is connected to the module bus through an RS-485 serial channel.

The CO_2 sensor preamplifier board contains the EEPROM, preamplifier of IR thermopile sensors and temp sensor.

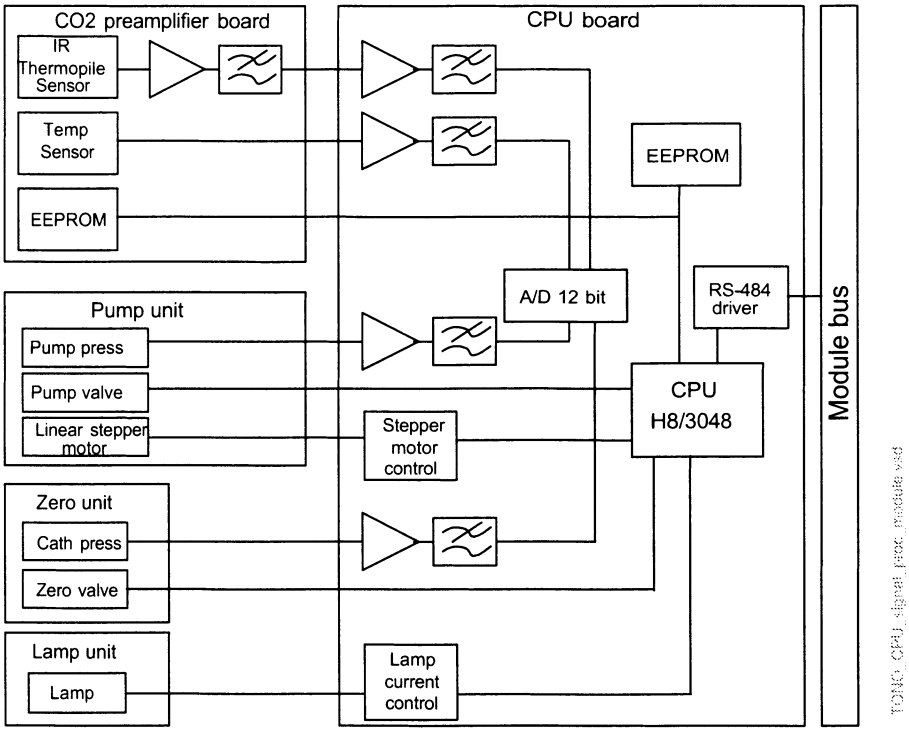

CO2 preamplifier board
IR Thermopile Sensor
Temp Sensor
EEPROM
CPU board
EEPROM
A/D 12 bit
RS-484 driver
Module bus
Pump unit
Pump press
Pump valve
Linear stepper motor
Stepper motor control
CPU H8/3048
Zero unit
Cath press
Zero valve
Lamp unit
Lamp
Lamp current control
TONO_CPU_signal_proc_module.vsd

Figure 6 **Signal processing of the module**

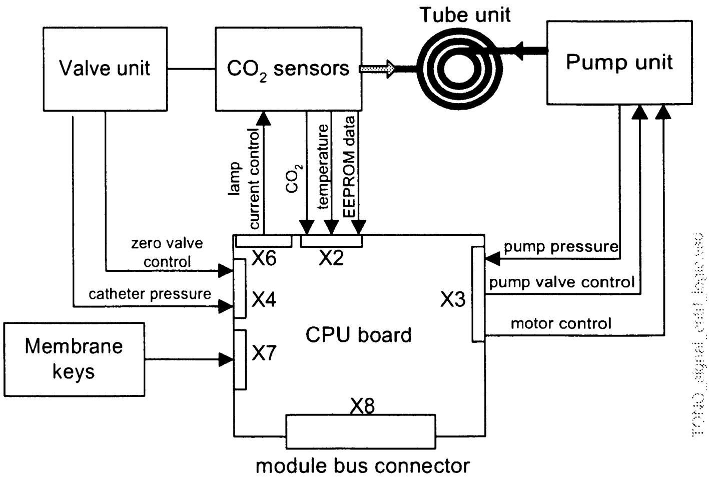
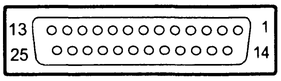

Tube unit
Valve unit
CO2 sensors
Pump unit
lamp current control
CO2
temperature
EEPROM data
zero valve control
catheter pressure
Membrane keys
X6
X2
X4
X7
X3
CPU board
pump pressure
pump valve control
motor control
X8
module bus connector
TONO_signal_cntrl_logic.vsd

Figure 7 **Signal and control logic**

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector	Pin No.	I/O	Signal
	1	I	RESET RS485
	2	I	-15 VDC (not used)
	3	I	+15 VDIRTY
	4	I	+15VDC
	5	I/O	-DATA RS485
	6	I/O	DATA RS485
	7		Ground and Shield
	8	I	-RESET RS485
	13		Ground and Shield
	14	I	+24/+32 VDIRTY Depends on power supply (not used)
	15	I	Ground DIRTY
	20	I	GASFR (not used)
	21	I	CTSD (not used)
	22	I	TXDD (not used)
	23	0	RXDD (not used)
	24	I	+5 VDC
	25	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the Tonometry module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed description of the fault.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

CAUTION The module electronics can only be repaired and calibrated at the factory.

3.1.1 CO_2 sensor

CAUTION The CO_2 sensor can only be repaired at the factory. Attempts to repair the sensor elsewhere will adversely affect operation of the sensor. The information provided is for reference only.

3.1.2 Factory calibration data

CAUTION If there is any fault in the CPU board, pump unit, valve unit or CO_2 sensor, the module should be sent to the factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit. The CO_2 sensor preamplifier board contains calibration data for the sensor itself and for gas measurement electronics on the CPU board.

3.1.3 Serviceable or exchangeable parts

- Nafion tube
- other tubings
- tube unit
- mechanical parts

NOTE: After any component replacement see section "Adjustments and calibrations"

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the checklist should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Torx screwdriver, T10	-	
Pressure manometer	-	
Silicon tube	73373	Available in meters.
Calibration gas Calibration gas regulator Calibration sampling line	755580 755534 733251	
Air pressure gauge	-	
Luer plug		
Tonometrics™ catheter		

See order numbers for accessories in the *Patient Monitor Supplies and Accessories* catalogue.

3.2.2 Recommended parts

Part	**Order No.**	**Notes**
Special tube, (Nafion) 300 mm	733382	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:
   - all screws are tightened properly
   - all cables are connected properly
   - tubes are not pinched and there are no sharp bends on them
   - all tubes are connected properly

   ✍

2. External parts
   Check that:
   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly

- the module box and latch are intact

✍

3. Nafion tube

   Replace the Nafion tube.

NOTE: The Nafion tube should be replaced annually.

✍

3.2.4 Functional inspection

4. Recognition

   Reattach the module box and check that the latch moves properly.

   Plug in the module. Check that it goes in smoothly and locks up properly.

   Turn the monitor on and wait until the normal monitoring screen appears.

   Configure the monitoring screen so that information regarding the tonometric measurement is shown, for example:

   Monitor Setup - ***Screen 1 Setup - Digit Fields -Lower Field 4 - PgCO2***

   Check that the module is recognized, i.e. the $PgCO_2$ header with related information appears in the chosen digit field.

   ✍

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Record the information regarding the software of the tonometry module by selecting ***Scroll Vers*** and turning the ComWheel.

   ✍

6. Communication and memories

   Enter the tonometric module service menu:

   ...***Parameters - More... - TONO***

   Check that the Timeouts, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK. Check that the general error status, module pneumatics error status, module hardware error status and testbit status are zero.

   ✍

7. Membrane keys

   Check the front panel **Start-Stop** and **Lab. Data** membrane keys.

Press each key for at least one second and check that the key being pressed is identified, i.e. the keyboard status changes.

✍

8. Pressure sensor calibration

   Perform the pressure sensor calibration (***TONO - PressSensCal***), see instructions in section "Pressure sensor calibration".

9. System test

   Perform the system test (***TONO - System Test***).

a. Block the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.
b. Select ***Start Test***.
c. Wait until the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in the "Service Menu" slot of the Monitor "Technical Reference Manual".

   The test can be interrupted at any time by selecting ***Stop Test***.

NOTE: The system test takes about one minute to carry out.

NOTE: Use a plug with very small volume to block the catheter port.

✍

10. Gas calibration

    Perform the gas calibration (***TONO - Tonometry - PgCO2 - Calibration***).

✍

11. Measurement

    Connect the catheter to the tonometry module. Start the tonometric measurement by pressing the **Start-Stop** key on the module.

    If the measurement is turned on $PgCO_2$ time bat replaces the Meas Off text. Check that the catheter fills up. Stop the measurement by pressing the **Start-Stop** key.

✍

12. Electrical safety check

    Perform an electrical safety check and a leakage current test.

✍

13. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

✍

14. Final cleaning

    Clean the module with suitable detergent.

✍

- Fill in all necessary documents.

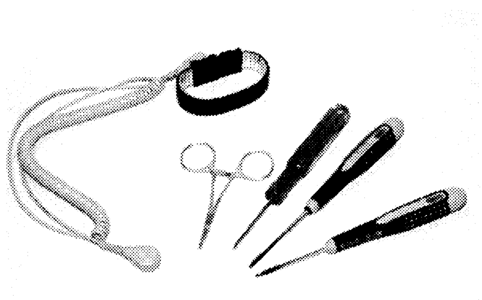
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the tonometry module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the tubes and cables are not pinched between the boards and the cover.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

3.3.4 Instructions after replacing tubings

After replacing any part of the tubings:

- perform the "System test"
- perform the "PgCO2 calibration"

3.4 Adjustments and calibrations

3.4.1 Pressure sensor calibration

Before the procedure:

- Find out what the ambient pressure is at the moment in [mmHg] or [mbar].
- Find a device with which you can apply a known pressure of about 100 mmHg to the catheter port. There are e.g. suitable blood pressure gauges. Make sure that it can be connected to a male luer connector.

1. The monitor prompts: 'Make sure that catheter connector is open to room air and start calibration.'
    - Remove the catheter, plug, pressure gauge or anything that is connected to the catheter port of the module.
    - Select ***Start Calib***
2. The monitor prompts: 'Calib started. Make sure that the catheter connector is open to room air.'
    - Remove the catheter, plug, pressure gauge or anything that is connected to the catheter port of the module, if you haven't done so already.
    - Wait a moment.
3. The monitor prompts 'Adjust ambient pressure.'
    - Turn ComWheel to match the highlighted pressure value (or the corresponding value in mbar to the right of the mmHg reading) to the known ambient pressure.
    - Press ComWheel.
4. The monitor prompts: 'Pump approximately 100 mmHg pressure and adjust cal. press. to match.'
    - Connect the blood pressure gauge to the catheter port.
    - Pump in pressure between 95 and 105 mmHg.
    - Turn ComWheel to match the highlighted pressure value to the applied pressure.
    - Press ComWheel.
5. The monitor prompts 'Store or discard new sensor gains and offsets.'
    - Turn ComWheel to display ***YES*** if you want to store the calibration factors or ***NO*** if you do not want to store them.
    - Press ComWheel.
6. The monitor prompts 'Calibration finished.'
    - Everything went OK and the calibration is finished.
    - OR
    - The monitor prompts: 'Calibration pressure too close to ambient pressure.'
    - The applied pressure was too low and you have to redo the calibration.

3.4.2 System test

1. Plug the catheter port of the module airtight e.g. with a plug that is made for closing a syringe.
2. Select ***Start Test***.
3. Wait till the automatic test procedure is over. The results are given in the data field and descriptions of the tested parts are listed in the Service Menu slot of the Monitor "Technical Reference Manual".

The test can be interrupted at any time by selecting ***Stop Test***.

NOTE: The system test takes about one minute to perform.

NOTE: Use a plug with very small volume to block the catheter port.

3.4.3 $PgCO_2$ calibration

The gas calibration is performed in the **Others** - ***Tonometry*** or ...***Service - Parameters - More... - TONO - Tonometry*** submenu.

1. Connect the calibration gas sampling line to the regulator and to the module's catheter connector.
2. Press the **Others** key on the monitor keyboard.
3. Select ***Tonometry - PgCO2 Calibration***.
4. Wait until the text 'Start feeding gas and press ComWheel. Feed gas until Adjust message is displayed' appears. Open the regulator and start feeding gas. Press ComWheel and continue feeding gas until the text 'Adjust' appears on the display.
5. Check that the displayed values match the values on the calibration gas container. Adjust with ComWheel if necessary.
6. It is recommended that the airway gases be calibrated at the same time.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	Cause/What to do
Tonometry module HW error.	Module hardware error. Return the module to the factory for repair.
Tonometrics catheter empty.	There is no gas in the tonometry catheter. It will be filled automatically during the next measurement. Occlusion in the catheter, or leak in the catheter or connector in the module. Check catheter.
Tonometrics catheter leakage.	The tonometry catheter is disconnected, the tubes are leaking inside the module or the catheter is leaking. Ensure proper catheter connection and have the internal leak repaired.
Unable to fill tonometrics catheter.	Occlusion in the catheter or the balloon is squeezed. Check catheter.

4.2 Gas sampling system troubleshooting

The faults which can occur in the sampling system are: leaks or blockages in the tubing, fault in pressure sensors, failure of the sampling pump or the magnetic valves.

The system test should help in localizing the fault. Whenever suspecting the sampling system and always after having done any work on the sampling system, check and if necessary adjust the pressure sensors.

CAUTION The special internal sample tube is mechanically fragile. Sharp bends will cause leaks.

CAUTION If there is any fault in the CPU board, pump unit, valve unit or CO_2 sensor, the module should be sent to factory for repair. The CPU board contains calibration data for the pressure transducers in the pump unit and valve unit.

NOTE: If any liquid has entered the module, contact GE Healthcare Technical Services.

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} Tonometry Module, E-TONO.

APPENDIX A Service check form, Tonometry Module, E-TONO (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. Nafion tube	☐	☐	☐				
Functional inspection							
4. Recognition	☐	☐	☐				
5. Module software	TONO						
6. Communication and memories	☐	☐	☐	7. Membrane keys	☐	☐	☐
8. Pressure sensor calibration	☐	☐	☐	9. System test	☐	☐	☐
10. Gas calibration	☐	☐	☐	11. Measurement	☐	☐	☐
12. Electrical safety check	☐	☐	☐	13. Functioning after electrical safety check			
14. Final cleaning	☐	☐	☐				

Notes

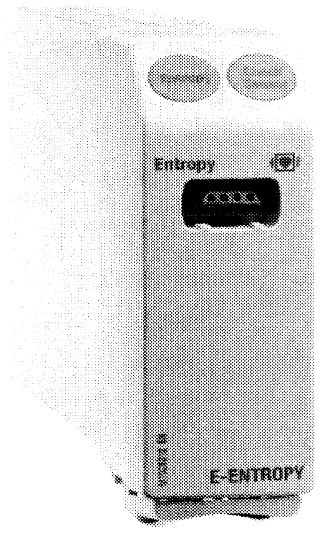
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Entropy Module, E-ENTROPY (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027831
June, 2005

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Entropy Module, E-ENTROPY. The Entropy module is a single width plug-in module designed for use with the Datex-Ohmeda Anesthesia Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Datex-Ohmeda S/5 Entropy Module, E-ENTROPY, and accessories are indicated for monitoring the state of the central nervous system (CNS) by data acquisition of electroencephalograph (EEG) and frontal electromyograph (FEMG) signals in the anesthesia environment. The spectral entropies, State Entropy (SE) and Response Entropy (RE), are processed EEG and FEMG variables, and may be used as an aid in monitoring the effects of certain anesthetic agents.

The Entropy module uses an electroencephalography (EEG) signal, together with spontaneous facial muscular activity with a frontal electromyography (FEMG) signal to measure:

- Response Entropy (RE)
- State Entropy (SE)
- Burst Suppression Ratio (BSR)

The Entropy module is responsible for EEG and FEMG signal acquisition, amplification, filtering and digitization and electrode impedance measurement. All the calculated parameters can be selected on the display, and trended.

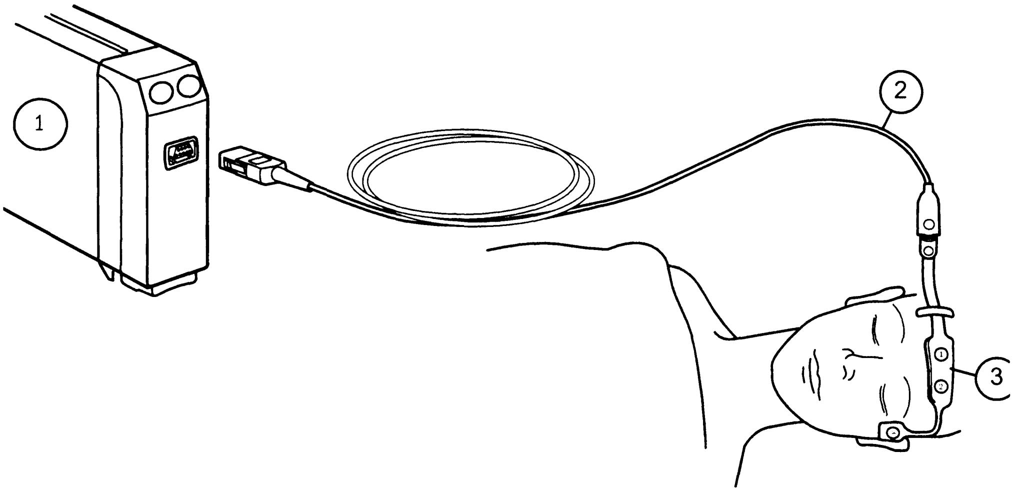


Figure 1 **Measurement setup**

(1) Entropy module
(2) Entropy sensor cable
(3) Entropy sensor

Monitor software compatibility

The Entropy Module, E-ENTROPY requires monitor software version 03 or greater.

1 Specifications

1.1 General specifications

Module size (W x D x H)	37 x 186 x 112 mm/1.5 x 7.3 x 4.4 in
Module weight	0.35 kg/0.8 lb.
Power consumption	2.6 W

1.2 Technical specifications

1.2.1 Entropy

Amplifier	
Amplification	10 000
Input dynamic range	±500 µV
Input offset	±300 mV
Frequency range	0.5 - 118 Hz
Noise level	<0.5 µV @ 0.5 - 118 Hz
Input impedance	1 MΩ @ 50 Hz
CMRR	>100 dB
Defibrillation protection	3000V, 130 J
A/D conversion	
Sampling frequency	1600 Hz
Resolution	60 nV
Waveform display (One channel of raw EEG)	
Range	800 µV$_{pp}$
Scales	±25/50/100/250/400 µV
Sweep speed	12.5/25/50 mm/s
Numeric display (RE, SE and BSR)	
Range	RE 0 - 100 SE 0 - 91 BSR 0 - 100%
Accuracy	±1 or ±1%
Display resolution	1 digit
Display update	1 s
Impedance measurement	
Measurement frequency	75 Hz
Current	10 µA
Range	0...30 kΩ
Resolution	0.1 kΩ
Accuracy	±1 kΩ or ±10%
Measurement time, all leads	5 s
Start of measurement	manual/automatic
Leads off detection	> 3 MΩ, continuous

2 Functional description

2.1 Measurements principle

The hypnotic component of anesthesia is most reliably monitored by measuring cortical electrical activity. Electroencephalography (EEG) changes from irregular to more regular patterns when anesthesia deepens. Similarly, frontalis EMG (FEMG) quiets down as the deeper parts of the brain are increasingly saturated with anesthetics. Entropy measures irregularity of EEG and FEMG.

Entropy parameters and BSR are calculated from EEG and FEMG signals acquired with a sensor which is attached to the patient's forehead. The sensor consists of three electrodes. This referential measurement yields one channel of raw EntrEEG.

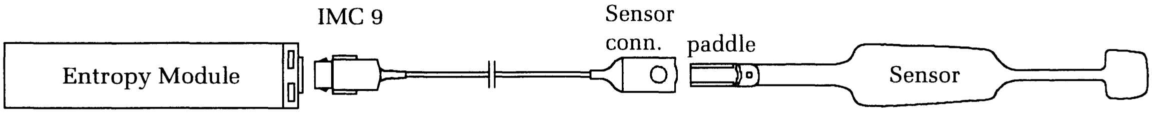


Figure 2 **A general view of the cable connections**

2.1.1 EntrEEG

EEG is a differential voltage signal measured from electrodes attached the patient's skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain. In referential measurement, the referential electrode delivers its potential to every channel's minus-input. The signal is the potential difference between this common reference electrode (electrode #3) and the electrode connected to the plus input (electrode #1). The purpose of the ground electrode (electrode #2) is to reduce common mode noise.

The EntrEEG signal is amplified, antialias filtered, digitized and software filtered. After that, the EntrEEG signal is shown on the screen and the RE, SE and BSR characteristics are calculated out of it.

2.1.2 FEMG

FEMG is an electrical signal originating from facial muscles. The FEMG signal has much broader spectrum than EEG and it overlaps with EEG at low frequencies. The FEMG signal gives its contribution to the RE values (see chapter 2.1.3). Mains power frequency and its harmonics are digitally filtered away to reject interference noise from power lines.

2.1.3 RE and SE

Entropy numbers range from 100 to zero (RE 0-100, SE 0 - 91), correlating to the patient's anesthetic state. High values of Entropy indicate high irregularity of the signal, signifying that the patient is awake. There are two Entropy parameters: the fast-reacting **Response Entropy** and the more steady and robust **State Entropy**. State Entropy consists of the entropy of EEG signal calculated up to 32 Hz. Response Entropy includes additional high frequencies up to 47 Hz and, consequently, the fast frontalis EMG (FEMG) signals enable a fast response time.

Table 1 **Frequency ranges for Entropy calculation**

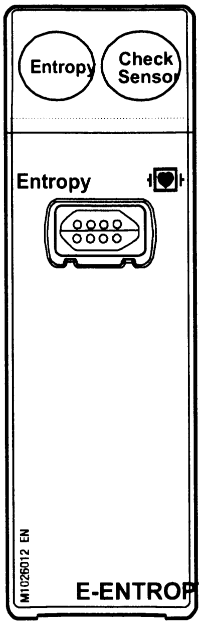
Response Entropy, RE	$0 < f < 47$ Hz
State Entropy, SE	$0 < f < 32$ Hz

2.1.4 Impedance measurement

The impedance measurement is performed for all leads at the same time and the EntrEEG is stopped for no longer than 5 seconds during the impedance measurement.

Differences in the electrode impedance of the electrodes cause common mode noise coupling to the measured signal. To minimize this, the electrode impedance is measured and a warning of an unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved.

2.2 Main components



Entropy: Opens the ***Entropy*** menu on the screen

Check Sensor: Starts the manual sensor check

Figure 3 Front panel of Entropy Module, E-ENTROPY

The Entropy board consists of the following functional sections:

- Microprocessor for measurement control, and for processing the measurement signal
- Digital I/O circuit for smart chip communication (the chip is located in the entropy sensor)
- Serial communication driver for module bus communication

The serial bus speed to the monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

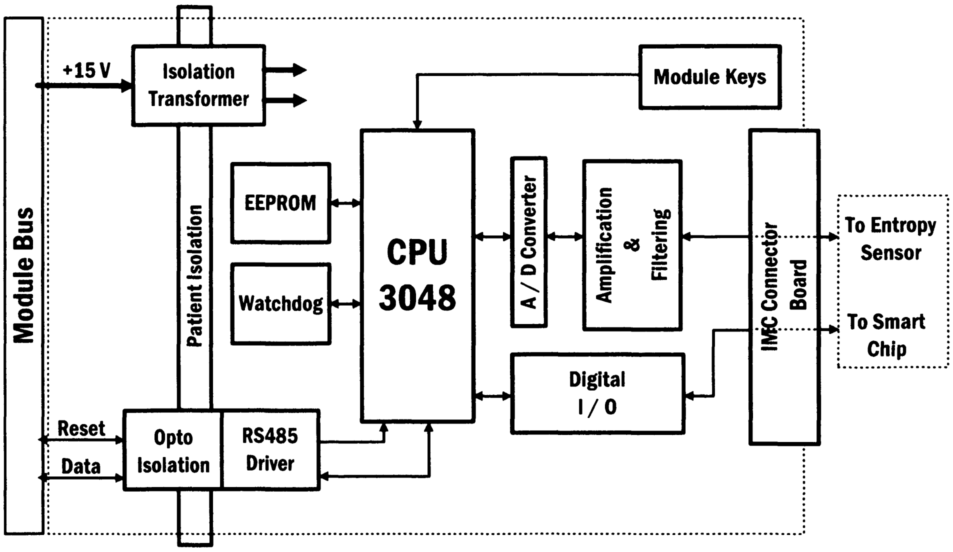
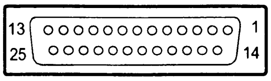

Module Bus
+15 V
Isolation Transformer
Patient Isolation
Reset
Data
Opto Isolation
RS485 Driver
EEPROM
Watchdog
CPU 3048
Module Keys
A / D Converter
Amplification & Filtering
Digital I / O
IMC Connector Board
To Entropy Sensor
To Smart Chip

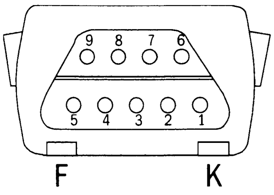
Figure 4 **Entropy measurement system block diagram**

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	**Pin No.**	**Name**	**Despcription**
Female D25  	1	Reset_ RS485	Module Bus Reset +
	3	+15VD	+15V Supply voltage
	5	Ndata_ RS485	Module Bus Data -
	6	Data_ RS485	Module Bus Data +
	7	GND	Ground
	8	Nreset_ RS485	Module Bus Reset -
	13	GND	Ground
	Other	NC	Not Connected

2.3.2 Module front panel connector

Module front panel connector	**Pin No.**	**Name**	**Color**	**Description**
 	1	VCC	PURPLE	Supply voltage
	2	I/O	WHITE	Bi-directional data line (open drain)
	3	CLOCK	BLUE	Clock input
	4	RESET	YELLOW	Control input (reset)
	5	GND	GREY	Smartchip ground
	6	Screen	-	Cable screen
	7	Electrode 2 (N)	GREEN	EEG channel neutral
	8	Electrode 3 (-)	RED	EEG channel -
	9	Electrode 1 (+)	BROWN	EEG channel +

3 Service procedures

3.1 General service information

The field service of the E-ENTROPY module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The simulator for E-ENTROPY (order code N-ES) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service check should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") Service check form, which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Simulator for E-ENTROPY	N-ES	
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts of the module
   Check that:
   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module
   - there are no loose objects inside the module

   ✍

2. External parts of the module

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the Entropy measurement is shown:

Monitor Setup - *Screen 1 Setup - Waveform Fields - Field 1 - EntrEG*

Others - ***Entropy - Entr.EEG - 250 μV***
Others - ***Entropy - Display format - All***
Others - ***Entropy - Automatic check - OFF***

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly.

   ✍

4. Recognition of module

   Check that the module is recognized, i.e. the EntrEEG header with related information appears in the chosen waveform fields and 'Cable off' message is shown on the field.

   ✍

5. Recognition of sensor

   Connect the cable to the module. Check that the cable is recognized i.e. message 'No sensor' is shown on the waveform field. If the Entropy sensor is connected, 'Sensor off' message appears.

   ✍

6. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Record the information regarding the software of E-ENTROPY by selecting ***Scroll vers*** and turning the ComWheel.

   ✍

7. Communication and memories of module

   Enter the Entropy module service menu:

   Parameters - More... - Entropy

Check that the Time-outs, Bad checksums and Bad c-s by mod values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

✍

8. Membrane keys

   Check the **Entropy** and **Check Sensor** membrane keys of the module. Go to the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the Check Sensor text is highlighted in the service menu and that pressing the **Entropy** key brings up the Entropy menu.

   ✍

9. Impedances

   Connect the Entropy simulator (N-ES) to the cable. Go to the ***Entropy*** service menu and select ***Check Sensor.*** In the Sensor view, check that the impedances in all three leads are 0 kΩ.

   ✍

10. Checks with simulator

    Keep the Entropy simulator connected and check that the EntrEEG waveform and RE and SE values appear on the monitor screen. The RE and SE values start to decrease after a couple of minutes.

    ✍

11. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

12. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

13. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

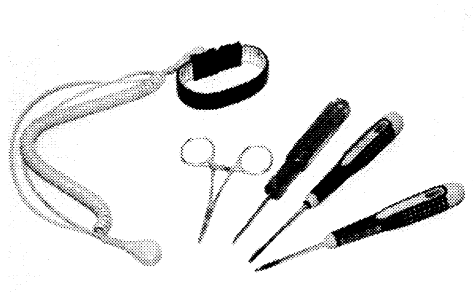
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the E-ENTROPY module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the Entropy board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check " after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Trouble	**Cause**	**What to do**
No EntrEEG waveform on screen.	EntrEEG waveform not selected on screen.	Press **Monitor Setup** key and select EntrEEG waveform on the screen.
No EntrEEG waveform on screen and 'Sensor off' message shown in the number field.	Entropy sensor not attached to skin.	Attach sensor to patient.
Number field shows '- - -' and message 'Sensor check failed' is displayed in number field.	Module could not accomplish a successful sensor check.	Check the sensor connection to skin and initiate a new check by pressing **Check sensor** module key or from ***Entropy*** menu.
EntrEEG signal looks noisy and 'Noise' message is displayed in the number field and waveform field	High frequency electrical interference (i.e. electrocautery) is coupling to the sensor.	Remove noise sources if possible. Check the sensor and electrode impedances.
Sensor check measurement is not available on menus.	Measurement is off because sensor is not connected to cable and to patient.	Sensor check starts immediately when sensor is connected to the patient and first Entropy values should appear 15 seconds after successful sensor check.
Electrode impedances show 'Fail'and 'Press electrodes' message is displayed on number fields after impedance measurement.	One or more of sensor electrodes is poorly connected to patient.	Check the sensor contact and cable. If the sensor electrodes have too high impedance (>7.5k), the measurement fails even if the sensor seems properly attached. Cure for this is to prepare the skin better, check that the sensor is not dried out or outdated and try again.

4.2 Troubleshooting flowcharts

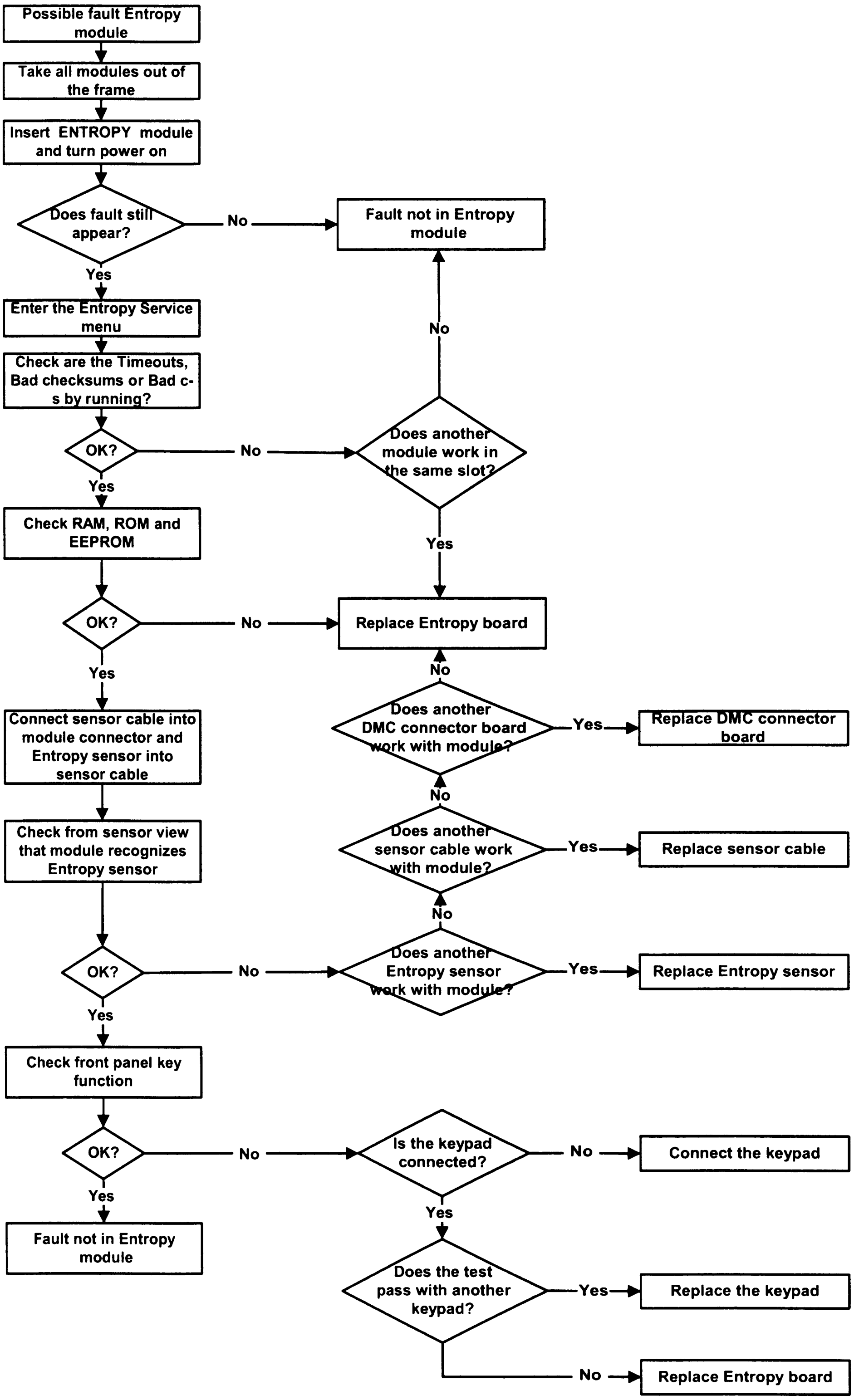

Possible fault Entropy module
Take all modules out of the frame
Insert ENTROPY module and turn power on
Does fault still appear?
No
Fault not in Entropy module
Yes
Enter the Entropy Service menu
Check are the Timeouts, Bad checksums or Bad c-s by running?
OK?
No
Does another module work in the same slot?
Yes
Check RAM, ROM and EEPROM
OK?
No
Replace Entropy board
Yes
Connect sensor cable into module connector and Entropy sensor into sensor cable
Does another DMC connector board work with module?
Replace DMC connector board
Check from sensor view that module recognizes Entropy sensor
Does another sensor cable work with module?
Replace sensor cable
OK?
Does another Entropy sensor work with module?
Replace Entropy sensor
Check front panel key function
OK?
Is the keypad connected?
Connect the keypad
Fault not in Entropy module
Does the test pass with another keypad?
Replace the keypad
Replace Entropy board

Figure 5 **Entropy module troubleshooting flowchart**

5 Earlier revisions

There are no earlier revisions of the S/5™ Entropy Module, E-ENTROPY.

APPENDIX A Service check form, Entropy Module, E-ENTROPY (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts of the module	☐	☐	☐	2. External parts of the module	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition of module	☐	☐	☐
5. Recognition of sensor	☐	☐	☐				
Notes							
6. Module software	E-ENTROPY						
7. Communication and memories of module	☐	☐	☐				
8. Membrane keys	☐	☐	☐				

9. Impedances	+	-	
Lead 1			1...3 k
Lead 2			1...3 k
Lead 3			1...3 k
10. Checks with simulator			Allowed range
EntrEEG waveforms			245...255
RF value			8...12
SE value			8...10
Notes			

	OK	N.A.	Fail		OK	N.A.	Fail
11. Electrical safety check	☐	☐	☐	12. Functioning after electrical safety check	☐	☐	☐
13. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

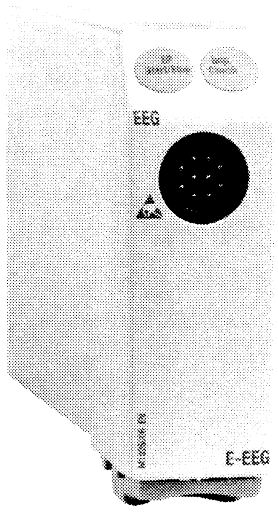
Signature

Datex-Ohmeda

EEG Module

S/5™ EEG Module, E-EEG (Rev. 00)
S/5™ EEG Headbox, N-EEG (Rev. 01)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027832
June, 2005

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Appendix A: Service check form,
EEG Module, E-EEG (Rev. 00) and EEG Headbox, N-EEG (Rev. 01) A-1

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 EEG Module, E-EEG, and the Datex-Ohmeda S/5 EEG Headbox, N-EEG. The EEG module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The EEG module and the EEG headbox together measure:

- electroencephalography (EEG)
- spontaneous facial muscular activity with frontal electromyography (FEMG)
- auditory evoked potentials (AEP)

The EEG Headbox, N-EEG, is responsible for EEG and FEMG signal amplification, filtering and digitization and electrode impedance measurement. It is situated close to the patient’s head. The Headbox has connectors for the EEG leads, either for a referential or a bipolar montage, and for the AEP stimulation earphones.

The EEG module E-EEG creates auditory stimulus pulses and takes care of AEP signal processing. It has one connector for the EEG headbox.

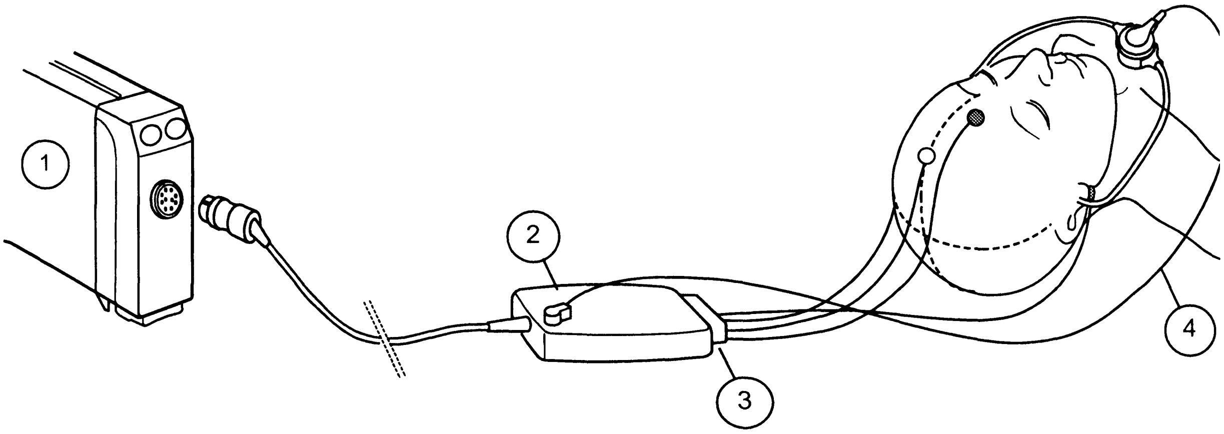


Figure 1 Measurement setup

(1) Module EEG, EP and FEMG measurement capability, E-EEG

(2) EEG Headbox and cable, N-EEG

(3) EEG leadset: preconfigured or own montage
- EEG electrodes (cup, needle or stick-on)

(4) Earphones (for AEP, earphones (4) are required)

Monitor software compatibility

The S/5 EEG Module, E-EEG and Headbox N-EEG function only with monitor software of level 99 or later.

1 Specifications

1.1 General specifications

1.1.1 Headbox

Box size, W × D × H	97 × 174 × 34 mm/3.8 × 6.9 × 1.3 in
Box weight	0.4 kg/0.9 lb.
Power consumption	1.9 W

1.1.2 Module

Module size, W × D × H	37 × 186 × 112 mm/1.5 × 7.3 × 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	3.1 W

1.2 Technical specifications

1.2.1 EEG

Amplification	10 000
Resolution	60 nV
Max amplitude	800 μV_{pp}
Sampling frequency	100 Hz per channel
Range	±400 µV
Frequency range	0.5...30 Hz
Input impedance	8 MΩ @ 10 Hz
Noise level	< 0.5 µV rms from 0.5 Hz to 30 Hz
CMRR	>100 dB @ 50 Hz
Parameters from power spectrum	SEF, MF, relative power in frequency bands
Burst suppression	calculated burst-suppression ratio (BSR)
Defibrillation protection	5000V, 360 J
Allowable Input Offset	±300 mV

1.2.2 AEP

Amplification	10 000
Resolution	60 nV
Max amplitude	1000 μV_{pp}
Stimulation	
Click (condensating)	duration 100 µs
Frequency	1.1...9.1 Hz (1 Hz steps) @ 10 ms measurement
	1.1...8.1 Hz (1 Hz steps) @ 100 ms measurement
Intensity	10...90 dB nHL, 10 dB steps

Measurement	
Sampling frequency	2400 Hz for MLAEP/ 4800 Hz for BAEP
Frequency range	0.5...1000 Hz
Highpass filter	off/10/30/50/75/100/150 Hz
Single average:	
Averaged responses	100...2000
Moving average:	
Gross average	100...2000
Update interval	after every 100 stimuli (200, when gross average is 2000)

1.2.3 EMG

Amplification	50 000
Resolution	100 nV
Max amplitude	100 μV_{pp}
Frequency range	60...300 Hz
Amplitude	Root Mean Square (RMS)

1.2.4 Impedance measurement

Measurement frequency	75 Hz
Current	10 μA
Range	0...30 kΩ
Resolution	100
Accuracy	±1k or ±10% whichever is greater
Measurement time, all leads	3 s
Start of measurement	manual/automatic
Leads off detection	>3 MΩ, continuous

2 Functional description

2.1 Measurement principle

2.1.1 EEG

EEG is a differential voltage signal measured from electrodes attached to the patient's skin. EEG measures the spontaneous electrical activity of the brain. This electrical activity reflects the state of the brain.

Electrode connections can be made with two different principles: bipolar or referential montage. In bipolar montage, every channel has two electrodes and the signal is the potential difference between these two electrodes. In referential montage, the referential electrode delivers its potential to every channel's minus-input. The signal is the potential difference between this common reference electrode and the electrode connected to the plus input. The purpose of the ground electrode is to reduce common mode noise. It cannot be used as referential electrode.

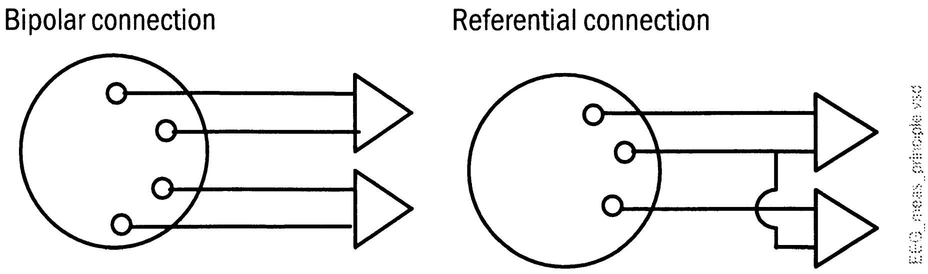


Figure 2 EEG measuring principle

The EEG signal is amplified, antialias filtered, digitized and software filtered. After that the EEG signal is displayed on the screen and various characteristics are calculated from it. These include spectrum, rms amplitude, spectral edge frequency, median frequency, burst-suppression ratio and percentage of total power in four different bands: theta (1...4 Hz), delta (5...9 Hz), alpha (9...13 Hz) and beta (>13 Hz).

2.1.2 FEMG

FEMG is an electrical signal originating from facial muscles. In the headbox, the signal of channel 1 is divided into two different amplification and filtering paths. One is the EEG path and the other is the FEMG path. The FEMG signal has a much broader spectrum than the EEG and it overlaps with the EEG at low frequencies. Because of this, the rms amplitude of FEMG signal is calculated from the frequency band 60...300 Hz. The mains power frequency and its harmonics are digitally filtered away to reject noise interference from power lines.

2.1.3 AEP

AEP is an electrical response of the nervous system to external auditory stimulus. It is measured using the same electrodes as in the EEG measurement, but the sampling frequency and bandwidth are different. The electrical signal resulting from one stimulus is weaker than the spontaneous activity of the brain. To overcome this, the stimulus is repeated several times (100...2000), and an average of all responses is calculated. Responses containing large artefacts are removed from the average to improve the signal to noise ratio.

2.1.4 Impedance measurement

The impedance measurement is performed from one channel at a time and the EEG or EP measurement is stopped during the impedance measurement.

Differences in electrode impedance cause common mode noise coupling to the measured signal. To minimize this, the electrode impedance is measured and a warning of unsatisfactory impedance level is generated when necessary. The impedance of an electrode is measured by applying a known current through the electrode and measuring the voltage drop over the electrode. This way the impedance of a single electrode can be resolved instead of a sum impedance of an electrode pair.

2.2 Main components

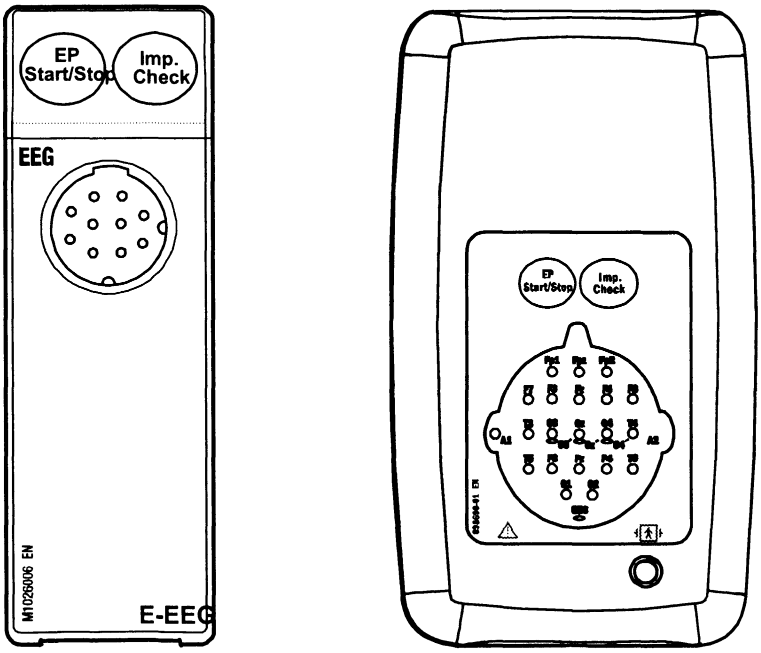


Figure 3 **Front panel of EEG Module, E-EEG, and of EEG Headbox, N-EEG**

EP Start/Stop	Starts/stops evoked potential measurement with the defined settings.
Imp. Check	Starts the manual measuring of the electrode impedance.

Headbox

The headbox, N-EEG, amplifies and digitizes the EEG signal. It has connectors for the EEG electrode leads and AEP simulation headphones. There are the same two keys as on the E-EEG: **EP Start/Stop** and **Imp. Check**. The headbox is situated close to the patient's head.

2.2.1 Neuro board

The Neuro board consists of the following functional sections:

- audio stimulator
- microprocessor for stimulation and measurement control, and for counting the measurement results

- two serial communication drivers

The serial bus speed to monitor is 500 kbps and the bus itself is half duplex, i.e. data can be transferred to both directions but only one way at a time.

The serial bus speed to the headbox is 500 kbps and the bus is full duplex i.e. data can be transferred to both directions at the same time.

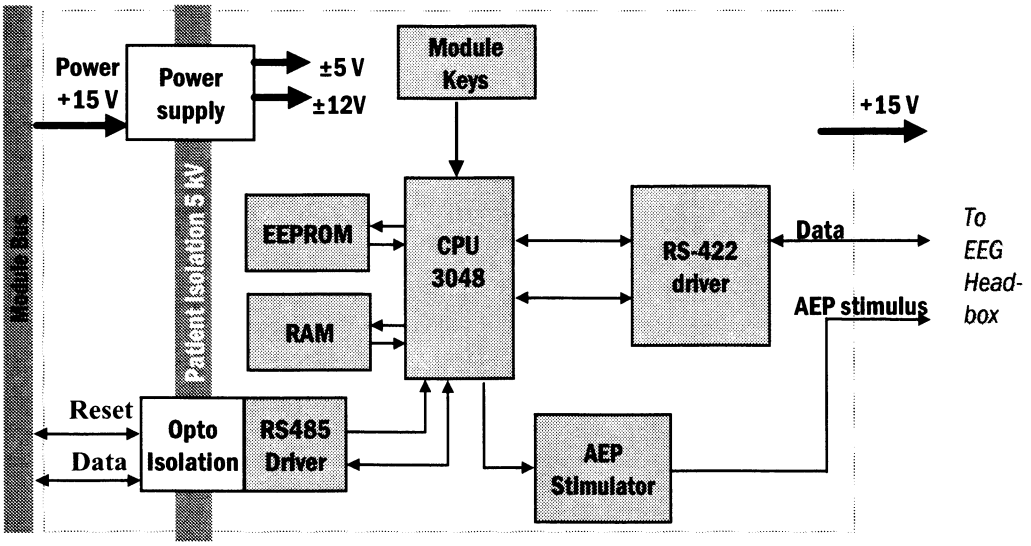

Module Bus
Power
+15 V
Power supply
±5 V
±12V
Patient Isolation 5 kV
Module Keys
+15 V
EEPROM
RAM
CPU 3048
RS-422 driver
Data
AEP stimulus
To EEG Head-box
Reset
Data
Opto Isolation
RS485 Driver
AEP Stimulator

Figure 4 **Neuro board block diagram**

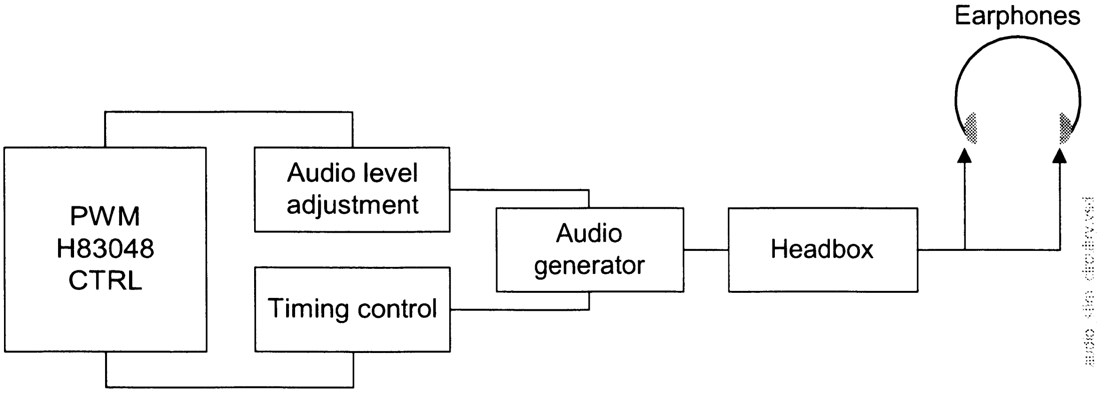

Earphones
PWM H83048 CTRL
Audio level adjustment
Timing control
Audio generator
Headbox

Figure 5 **Audio stimulator circuitry**

2.2.2 Headbox board

The Headbox board consists of the following functional sections:

- input protection
- EEG amplifiers and filters
- FEMG amplifier and filter
- current feeding circuitry and amplifiers for impedance measurement

- microprocessor
- serial communication

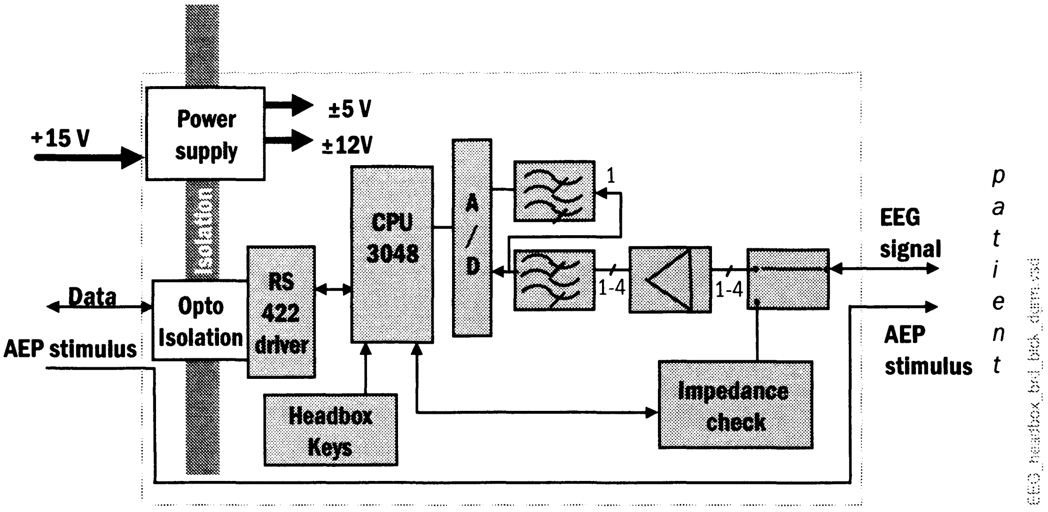
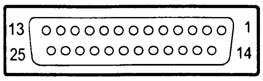

Power supply
+15 V
±5 V
±12V
Isolation
Data
AEP stimulus
Opto Isolation
RS 422 driver
CPU 3048
Headbox Keys
A / D
1
1-4
1-4
Impedance check
EEG signal
AEP stimulus
patient

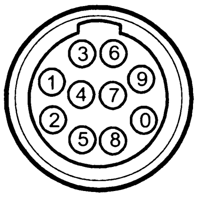
Figure 6 **EEG headbox board block diagram**

2.3 Connectors and signals

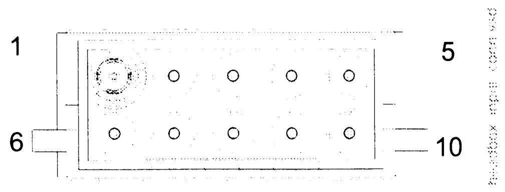
2.3.1 Module bus connector

Module bus connector (X1)	**Pin No.**	**I/O**	**Signal**
	1	I	RESET_RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	I	CTSB
	10	O	RTSB
	11	I	RXDB
	12	O	TXDB
	13	-	Ground & Shield
	14	I	+32 VDIRTY
	15	I	GroundDIRTY
	16	I	CTSC
	17	O	RTSC
	18	I	RXDC
	19	O	TXDC
	20	-	ON/STANDBY
	21	-	PWM_ECG
	22	-	RXDD_RS232
	23	-	TXDD_RS232
	24	I	+5 VDC
	25	I	+5 VDC

2.3.2 Headbox connector

Headbox connector	Pin No.	Signal
	1	Ground
	2	Ground
	3	+15 V
	4	TXD+
	5	EP Audio
	6	Power sync 43 kHz
	7	RXD+
	8	EP Sync
	9	RXD-
	0	TXD-

2.3.3 Headbox input connector

Headbox input connector	Pin No.	Signal
	1	Lead set id
	2	1+
	3	2+
	4	3+
	5	4+
	6	Ground
	7	1- / Ref
	8	2-
	9	3-
	10	4-

3 Service procedures

3.1 General service information

The field service of the E-EEG module and N-EEG headbox is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
EEG simulator	90502	No longer available *
Torx screwdriver, T10		
Earphones		

* In case no EEG simulator is available for checking, skip over the steps referring to the simulator.

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

Detach also the cover of the EEG headbox by removing the four screws from the bottom of the box. Be careful with the two wired connectors in the circuit board attached to the cover.

1. Internal parts of the module and the headbox:

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - the EMC cover is attached properly in the module

- there are no loose objects inside the module or the headbox

✍

2. External parts of the module
   Check that:
   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   ✍

3. External parts of the headbox
   Check that:
   - cover and the base of the headbox are intact
   - the headbox sticker is intact
   - connectors are intact and attached properly

   ✍

Reattach the module box and the cover of the EEG headbox.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the EEG measurement is shown:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - EEG1***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 2 - EEG2***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 3 - EEG3***
Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 4 - EEG4***

Others - ***EEG - Montage - EEG Channels - 4***
Others - ***EEG - Montage - Montage type - Bip***
Others - ***EEG - EEG Setup - Numeric 1 - MF***
Others - ***EEG - EEG Setup - Numeric 2 - Ampl.***

4. Installation
   Plug in the module. Check that it goes in smoothly and locks up properly

   ✍

5. Recognition of module
   Check that the module is recognized, i.e. the EEG header with related information appears in the chosen waveform fields and 'Headbox off' message is shown on the four fields.

   ✍

6. Recognition of headbox

   Connect the headbox to the module. Check that the headbox is recognized i.e. message 'EEG measurement off' is shown on the four waveform fields. If the EEG leads are connected, 'EEG measurement off' message disappears after 15 seconds.

   ✍

7. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Record the information regarding the software of E-EEG and N-EEG by selecting ***Scroll vers*** and turning the ComWheel.

   ✍

8. Communication and memories of module

   Enter the EEG module service menu:

   Parameters - More... - EEG & EP

   Check that the Timeouts, Bad checksums and Bad c-s by mod values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

   ✍

9. Communication and memories of headbox

   Check that the HB Mod Timeouts, HB Mod Bad Checksum and Mod HB Bad Checksum values are not increasing faster than by 5 per second. Check that the memory of the headbox has passed the internal memory test, i.e. HB Rom Error in the headbox view states 0.

   ✍

10. Membrane keys

    Check the **EP Start/Stop** and **Imp. Check** membrane keys both of the module and the headbox. Go to the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding text is highlighted in the service menu. Repeat in the headbox view with the headbox keys.

    ✍

11. Impedances

    Select 10 kΩ as imped. pos. and imped. neg. value on the simulator. Go to the ***EEG & EP*** service menu and select ***Check Electr.*** In the headbox view, check that the impedances in all four channels are 10 kΩ ±1 k.

    ✍

12. Checks with simulator

    Connect the EEG simulator to the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 10 Hz 200 µV sinewave on the simulator and check that all the four waveforms have the same form. Check that the size of the waveforms is 200 μV_{pp} ±5 µV. Check that the MF value is 10 ±0.5 Hz. Check that the amp value is 71 µV 3 µV.

13. FEMG value

    Select 75 Hz 50 µV signal on the simulator. Check that the FEMG value is 16 ±3 µV.

    Preset the AEP measurement settings:

    Others

    EP - Cycle - Cont.
    EP - AEP Setup - AEP Channels - 2
    EP - AEP Setup - Responses -100
    EP - AEP Setup - Stim. Frequency - 1.1Hz
    EP - AEP Setup - Stim. Intensity - 60 dB
    EP - AEP Setup - Sweep length - 100 ms

14. AEP stimulation

    Plug in the earphones to the headbox. Be careful with load stimulation from the earphones when starting AEP stimulation. Start AEP stimulation by pressing the **EP Start/Stop** button on the module. Check that the clicking sound comes from the earphones in 1.1 Hz frequency. Stop the stimulation by pressing again the **EP Start/Stop** button on the module. Check that the clicking stopped.

    Modify the AEP measurement settings:

    Others

    EP - AEP Setup - Stim. Frequency - 8.1Hz
    EP - AEP Setup - Stim. Intensity - 90 dB
    EP - EP Size - 1

15. AEP response

    Connect the AEP testing cable between the simulator and the headbox. Select 2 kΩ as imped. pos. and imped. neg. value on the simulator. Select 40 µV amplitude in the ***EP*** waves menu on the simulator and start AEP measurement in the **Others** - ***EP*** menu. Wait until you get the response on the display. Check that the shape of the response is one period of a sine wave. Save ***EP*** and adjust the markers to the minimum and maximum level of the response curve in both channels. Check that the amplitude is 40 V ±5 µV.

16. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

17. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

18. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

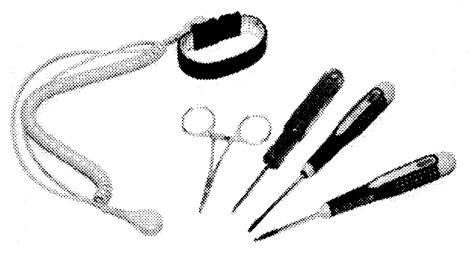
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

3.3.4 E-EEG

To disassemble the E-EEG module (see the exploded view of the EEG module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the Neuro board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

3.3.5 N-EEG

To disassemble the N-EEG headbox (see the exploded view of the headbox in the "E-Modules Spare parts" slot):

1. Remove the four screws from the bottom of the headbox.
2. Lift off the cover and disconnect the two cables connected to the EEG headbox board.
3. Disconnect the module-headbox cable and the headbox input unit connectors from the EEG headbox board.

4. Remove the four screws on the corners of the EEG headbox board and detach the EEG headbox board.

To reassemble the N-EEG, reverse the order of the disassembly steps.

CAUTION When reassembling the headbox, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the headbox.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
No EEG waveforms on screen.	EEG waveforms not selected on screen.	Press **Monitor Setup** key and select EEG waveforms on the screen.
No EEG waveforms on screen and 'EEG measurement off' message shown in the number field.	Electrodes not attached properly to skin or electrode cables not connected to headbox.	Check electrodes and electrode cables.
All EEG waveforms not drawn on screen even if electrodes and cables are OK.	The number of channels chosen on montage setup is smaller than the number of channels connected to patient.	Check that the number of channels in menu **Others** *-**EEG** - **Montage*** is the same as the number of channels connected to patient.
Number fields show '---' and message 'High EMG' is displayed.	Patient has high muscle activity in the head region or noise from some equipment is coupling to electrode cables.	Relax the patient or remove the noise source.
EEG signal looks noisy and artefact message is displayed in the number fields.	Electrodes are poorly connected or electrical interference is coupling to electrode cables.	Check the electrodes and electrode impedances. Remove noise sources if necessary.
'Leads off' message is shown on other channels than channel 1 in referential connection.	The montage chosen in monitor is not referential.	Change the montage to referential from monitor menu **Others** *-**EEG** - **Montage***.
Electrode impedance measurement is not available on menus.	EEG measurement is off.	EEG measurement starts 15 seconds after first electrode pair is connected.
Electrode impedance measurement is not available on menus.	EP measurement is on.	Wait until EP measurement ends or stop EP measurement.
Electrode impedances show '---' and 'Check ground electrode' message is displayed on number fields after impedance measurement.	Ground electrode is poorly connected to patient or ground electrode cable is not connected to headbox.	Check the electrode and cable. If the electrode has too high impedance (>50k), the measurement fails even if the electrode is properly attached. Cure for this is to use better electrodes or prepare the skin better.
Electrode impedances show '---'	The electrode impedances are too high and out of measurement range.	Prepare the skin better or use better electrodes.
Start EP measurement not available on EP menu.	The EEG measurement is off.	Connect electrodes and wait 15 seconds and the measurement starts.
EP measurement parameters cannot be changed.	The EP measurement is on.	Stop EP measurement.
All or most of the EP epochs are rejected (Rej. counter on EP screen increases more rapidly than Ave. counter).	The signal has too much noise/artefacts in EP measurement band. Especially coupled 50/60 Hz is not shown on EEG waveform because of filtering, but may be present in EP signal.	Check that electrode impedances are below 5k and the impedances of the same channel are close to one another. If this does not help, then try to remove noise sources.
EP wave is shown only on one channel even if two channels EP measurement is selected.	Leads are off in the channel where the EP wave is not shown.	Check the electrodes and electrode cables.
No clicks can be heard from earphones.	The earphones connector is not in place.	Check that the earphones plug is firmly pushed into the headbox's earphone connector.

4.2 Troubleshooting flowcharts

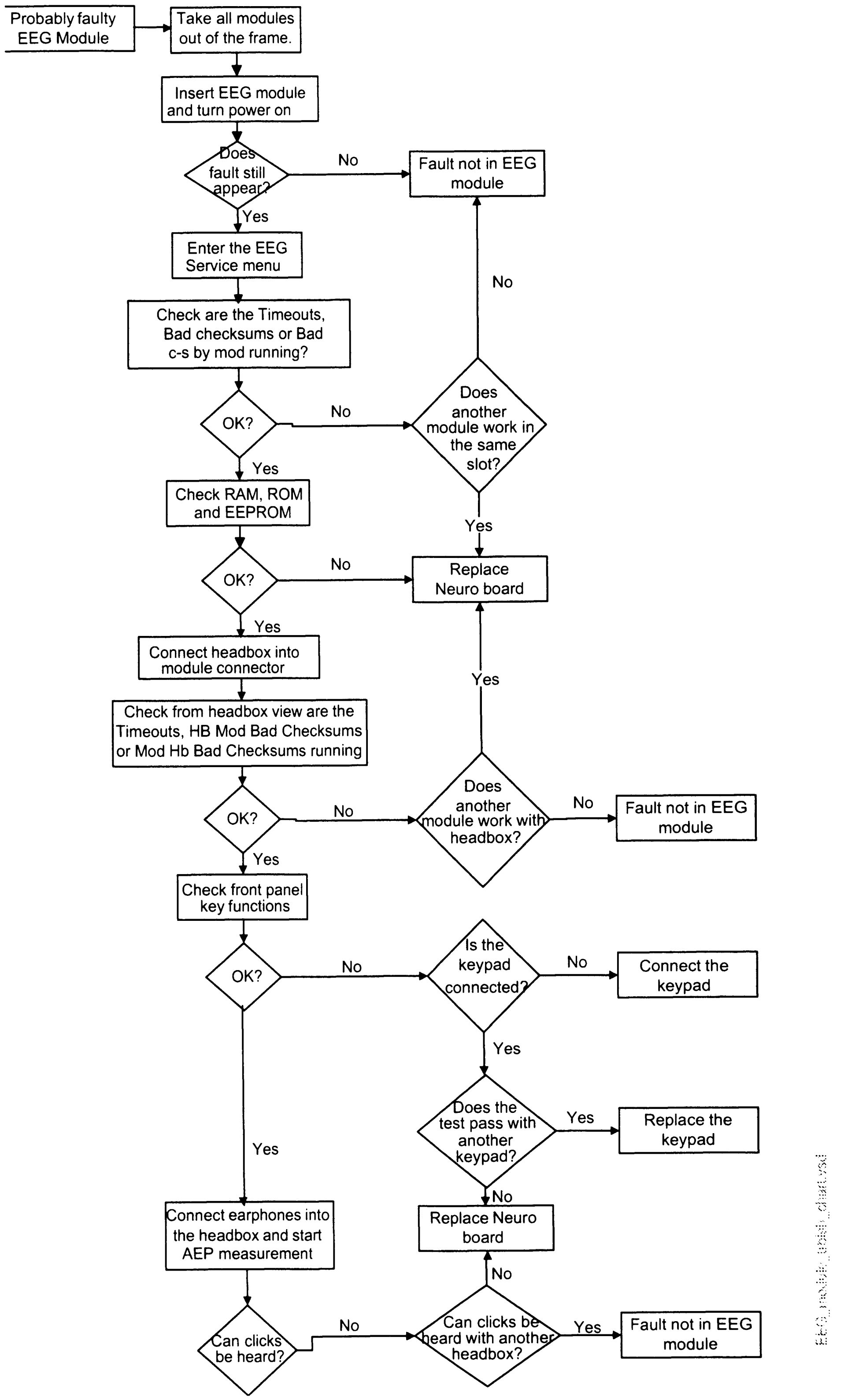

Probably faulty EEG Module
Take all modules out of the frame.
Insert EEG module and turn power on
Does fault still appear?
No
Fault not in EEG module
Yes
Enter the EEG Service menu
Check are the Timeouts, Bad checksums or Bad c-s by mod running?
OK?
No
Does another module work in the same slot?
No
Yes
Check RAM, ROM and EEPROM
Yes
OK?
No
Replace Neuro board
Yes
Connect headbox into module connector
Yes
Check from headbox view are the Timeouts, HB Mod Bad Checksums or Mod Hb Bad Checksums running
OK?
No
Does another module work with headbox?
No
Fault not in EEG module
Yes
Check front panel key functions
OK?
No
Is the keypad connected?
No
Connect the keypad
Yes
Does the test pass with another keypad?
Yes
Replace the keypad
Yes
No
Connect earphones into the headbox and start AEP measurement
Replace Neuro board
No
Can clicks be heard?
No
Can clicks be heard with another headbox?
Yes
Fault not in EEG module
EEG_module_tbsh_chart.vsd

Figure 7 **EEG module troubleshooting flowchart**

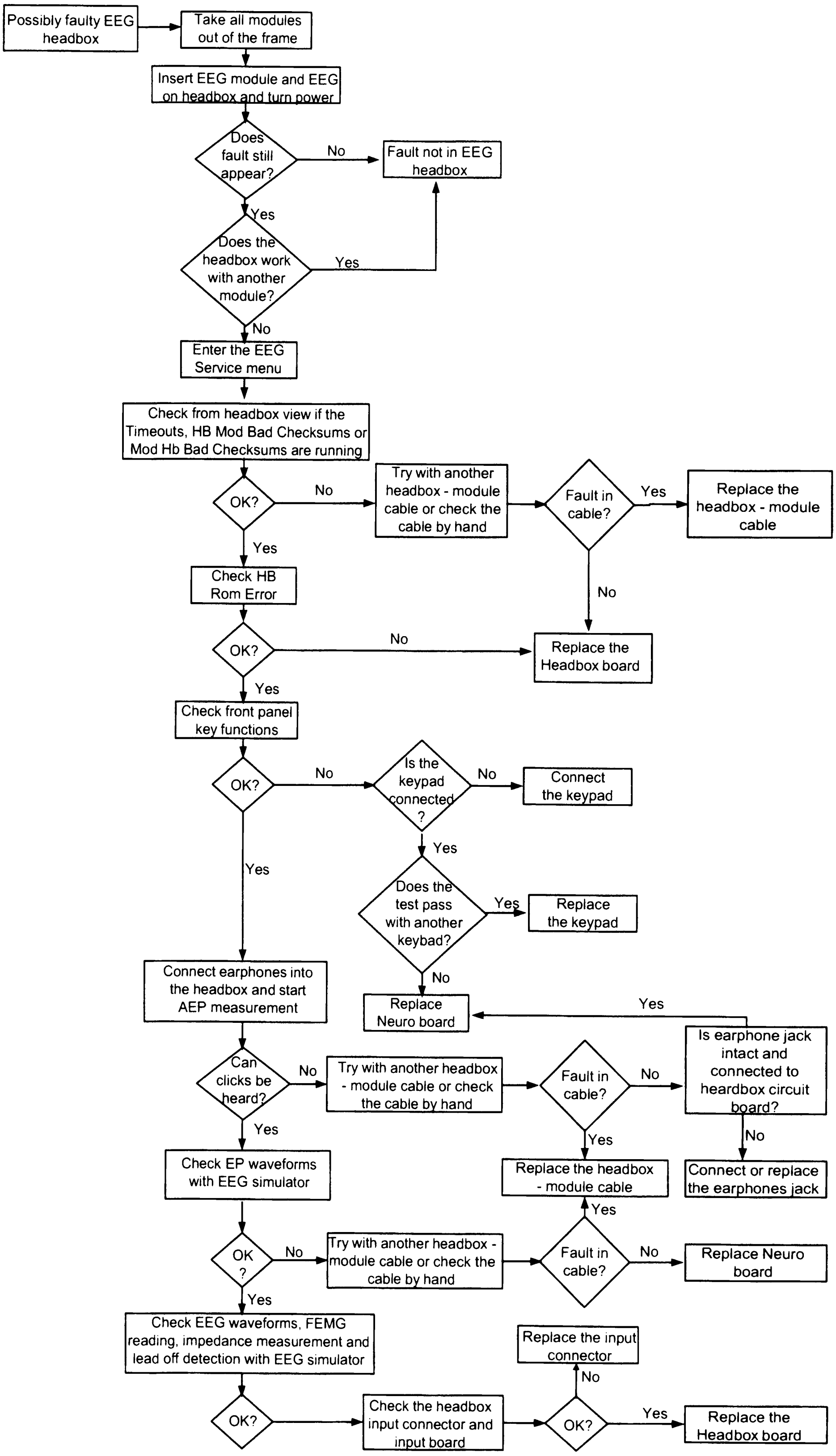

Possibly faulty EEG headbox
Take all modules out of the frame
Insert EEG module and EEG on headbox and turn power
Does fault still appear?
No
Fault not in EEG headbox
Yes
Does the headbox work with another module?
Yes
No
Enter the EEG Service menu
Check from headbox view if the Timeouts, HB Mod Bad Checksums or Mod Hb Bad Checksums are running
OK?
No
Try with another headbox - module cable or check the cable by hand
Fault in cable?
Yes
Replace the headbox - module cable
No
Yes
Check HB Rom Error
OK?
No
Replace the Headbox board
Yes
Check front panel key functions
OK?
No
Is the keypad connected?
No
Connect the keypad
Yes
Does the test pass with another keybad?
Yes
Replace the keypad
No
Replace Neuro board
Yes
Yes
Connect earphones into the headbox and start AEP measurement
Can clicks be heard?
No
Try with another headbox - module cable or check the cable by hand
Fault in cable?
No
Is earphone jack intact and connected to heardbox circuit board?
No
Connect or replace the earphones jack
Yes
Replace the headbox - module cable
Yes
Check EP waveforms with EEG simulator
OK?
No
Try with another headbox - module cable or check the cable by hand
Fault in cable?
Yes
No
Replace Neuro board
Yes
Check EEG waveforms, FEMG reading, impedance measurement and lead off detection with EEG simulator
OK?
Check the headbox input connector and input board
OK?
Yes
Replace the Headbox board
No
Replace the input connector

Figure 8 **Headbox troubleshooting flowchart**

5 Earlier revisions

There are no earlier revisions of the S/5™ EEG Module, E-EEG. This manual supports the earlier revisions of the S/5™ EEG Headbox, N-EEG.

APPENDIX A Service check form, EEG Module, E-EEG (Rev. 00) and EEG Headbox, N-EEG (Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts of the module and the headbox:	☐	☐	☐	2. External parts of the module	☐	☐	☐
3. External parts of the headbox	☐	☐	☐	4. Installation	☐	☐	☐
Notes							

Functional inspection							
4. Installation	☐	☐	☐	5. Recognition of module	☐	☐	☐
6. Recognition of headbox	☐	☐	☐				
7. Module software	E-EEG						
	N-EEG						
8. Communication and memories of module	☐	☐	☐	9. Communication and memories of headbox	☐	☐	☐
10. Membrane keys	☐	☐	☐				

11. Impedances		Measured value	Allowed range
Channel 1			9...11 kOhm
Channel 2			9...11 kOhm
Channel 3			9...11 kOhm
Channel 4			9...11 kOhm
Notes			

12. Checks with simulator		Measured value	Allowed range
Waveforms			195...205 μV_{pp}
MF			9.5...10.5 Hz
Amp value			68...74 μV
13. FEMG value		Measured value	Allowed range
	FEMG		13...19 μV
	OK **N.A.** **Fail**		**OK** **N.A.** **Fail**
14. AEP stimulation	☐ ☐ ☐		
15. AEP response		Measured value	Allowed range
Channel 1			35...45 μV
Channel 2			35...45 μV
16. Electrical safety check	☐ ☐ ☐	17. Functioning after electrical safety check	☐ ☐ ☐
18. Final cleaning	☐ ☐ ☐		

Notes

Used spare parts			

Signature

Datex-Ohmeda

S/5™ BIS Module, E-BIS (Rev. 00)

Technical Reference Manual Slot

All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027833
June, 2005

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Appendix A: Service check form,
BIS Module, E-BIS (Rev. 00) A-1

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 BIS Module, E-BIS. The BIS module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

BIS and the BIS logo are trademarks of Aspect Medical Systems Inc., and are registered in the USA, EU and other countries. Later in this manual Aspect Medical Systems Inc. will be referred to as Aspect.

The BIS module is indicated for monitoring the state of the brain by data acquisition of EEG signals. BIS may be used as an aid in monitoring the effects of certain anesthetic agents. The raw EEG signals are processed to produce a single number, ranging from 100 for a patient being wide awake to 0 in the absence of brain activity.

Calculated parameters are:

- Bispectral Index, BIS
- Suppression Ratio, SR
- Electromyograph EMG
- Signal Quality Index, SQI

The calculated parameters can be selected on the display, and trended (excluding SQI).

The module has two user keys, **BIS** for ***BIS*** menu and **Check Sensor** for impedance check.

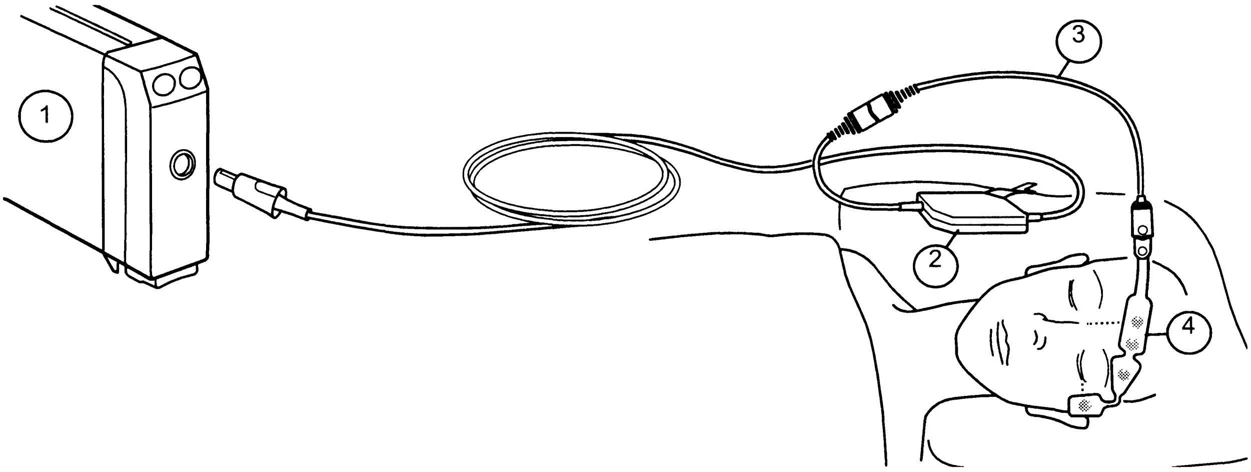


Figure 1 Measurement setup

(1) Module with BIS measurement capability, E-BIS
(2) Digital Signal Converter
(3) Patient Interface Cable
(4) BIS Sensor

Monitor software compatibility

E-BIS module requires monitor software version 02 or later.

Accessories

The BIS measurement is based on Aspect Medical Systems Inc. technology, and all accessories are developed and manufactured by Aspect.

NOTE: Only Aspect accessories can be used with the E-BIS module.

1 Specifications

1.1 General specifications

1.1.1 BIS Module

Module size, W × D × H	37 × 189 × 112 mm/1.5 × 7.4 × 4.4 in
Module weight	0.3 kg/0.7 lb.
Power consumption	2.2 W

1.1.2 Digital Signal Converter, DSC

DSC size, W × D × H	66 × 108 × 25 mm/2.6 × 4.3 × 1.0 in
DSC weight	0.134 kg/0.3 lb.
Integral DSC Cable length	3.6 m / 12.5 ft
Patient Interface Cable (PIC Plus) length	1.2m / 4 ft

1.1.3 Environmental specifications

Operating temperature	+10 ... +40°C
Storage temperature	-25 ... +70°C
Relative humidity	10 ... 95%, non-condensing
Atmospheric pressure	700 ... 1060 mbar
Protection against electrical shock	Type BF

1.2 Technical specifications

1.2.1 Parameter specifications

BIS EEG

Epoch duration	2 s
Artifact rejection	automatic
EEG scales	25 to 400 µV
EEG sweep speeds	12.5 / 25 / 50 mm /s
Bispectral index (BIS)	0 to 100
Signal quality index (SQI)	0 to 100
EMG	30 to 80 db (70 to 110 Hz)
Suppression ratio (SR)	0 to 100%
Update rate	1 s for BIS index
Filters	ON (2 to 70 Hz with notch), OFF (0.25 to 100 Hz)
Smoothing rate	15 s, default in S/5 AM and CAM 30 s, default in S/5 CCM and CCCM

DSC-XP (Digital Signal Converter)

Analog to digital converter	noise-shaped sigma-delta
Sampling rate	16 384 samples/s

Resolution	16 bits at 256 samples/s
Input impedance	> 50 Mohms
Noise	< 0.3 µV RMS (2.0 µV peak-to-peak) 0.25 to 50 Hz
Common mode rejection	110 dB at 50/60 Hz to earth ground (Isolation mode)
Bandwith	0.16 to 450 Hz

2 Functional description

2.1 Measurement principle

The BIS measurement is based on EEG signals, these are processed as the BIS index. The BIS sensor is placed on the patient's forehead to acquire the high-resolution signals required. These EEG signals are transferred to the digital signal converter DSC that amplifies and digitizes the EEG signal and sends it to the module. The module calculates the BIS index and sends both the signal and the index to the monitor via MBUS.

2.1.1 BIS measurement on the monitor screen

The waveform field shows the BIS EEG waveform. The following BIS related data appears in digit fields and graphical trends (except SQI):

BIS number indicates the patient's level of hypnosis, ranging from 100 for wide awake to 0 in the absence of brain activity.

Signal Quality Index (SQI) bar graph indicates the quality of the EEG signal in the range of 0 to 100.

Electromyograph (EMG) bar graph represents the absolute power in the 70 to 110 Hz frequency band and ranges from 30 to 55 dB. This frequency band contains power from muscle activity (electromyograph) as well as power from high frequency artifacts.

Suppression ratio (SR) number indicates the percentage of suppressed (flat line) EEG detected over the last 63 seconds. It ranges from 0 to 100%.

2.2 Sensor check

Sensor check is performed automatically at the beginning of each case when the sensor is attached to the patient interface cable (monitor). An initial 'Checking sensor' message is shown in the digit field together with an appropriate sensor picture. The information on the passed or failed sensor check is printed to this picture at each electrode's location. The BIS measurement cannot continue if the first sensor check fails. In such a case a message 'Sensor check failed' is shown in the digit and waveform field.

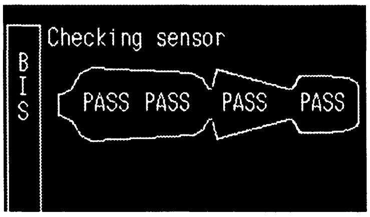

Checking sensor

Figure 2 **BIS sensor check**

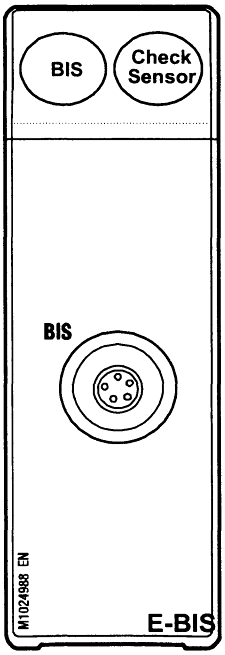
Continuous checking of the reference and signal electrodes and periodic checking of the ground electrode are performed by default. The automatic check can be switched off by selecting OFF in the BIS Setup menu, and the message 'Automatic check off' appears on the screen. Sensor check can be started manually by pushing a module key or selecting the appropriate command from the menu. Manual sensor check can be useful e.g. when AEP's are being monitored at the same time, as continuous sensor check might disturb the AEP measurement.

During periodic ground checks, the signal disappears momentarily and the message 'Checking sensor' is displayed in the digit and waveform fields. Also, all BIS calculation stops during this check, and no measurement values are shown.

CAUTION Continuous impedance check may need to be disabled if the 1 nA 128 Hz impedance check signal interferes with other equipment such as evoked potential.

WARNING **Make sure that the electrodes, sensor and connectors do not touch any electrically conductive material, including earth.**

2.3 Main components



BIS: Opens the ***BIS*** menu on the screen

Check Sensor: Starts the manual sensor check

Figure 3 Front panel of BIS Module, E-BIS

The BIS measurement chain is composed of Aspect BIS Sensor, Aspect digital signal converter, E-BIS module containing Aspect BIS Engine board and Datex-Ohmeda interfacing board, and a host monitor. A block diagram of the system is shown below.

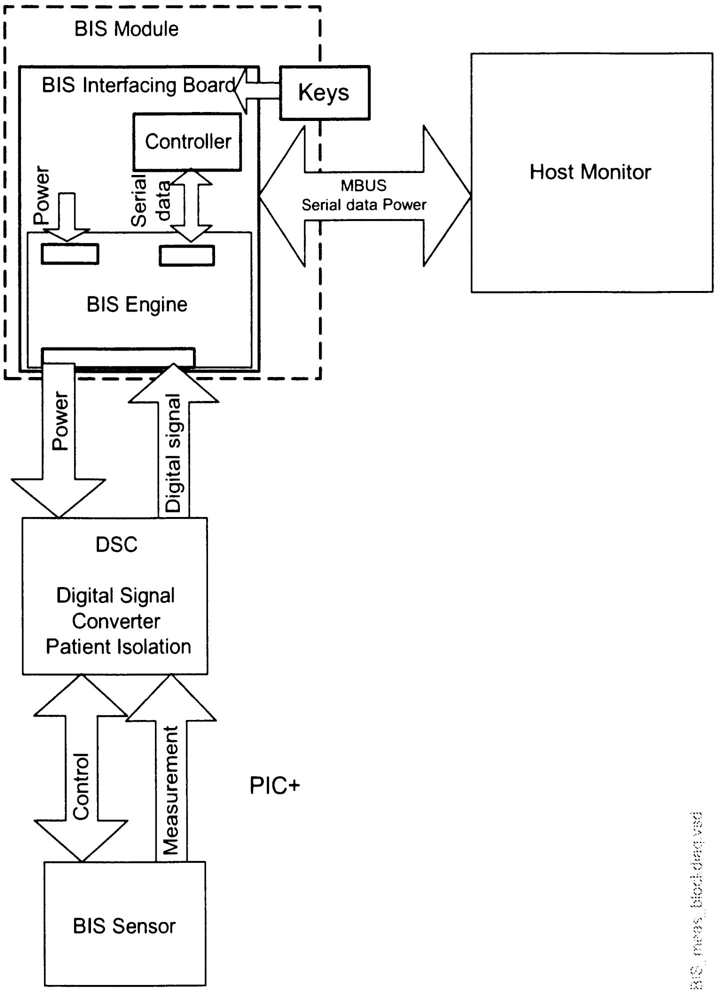

BIS Module
BIS Interfacing Board
Keys
Controller
Power
Serial data
BIS Engine
MBUS
Serial data Power
Host Monitor
Power
Digital signal
DSC
Digital Signal
Converter
Patient Isolation
Control
Measurement
PIC+
BIS Sensor
BIS_meas_block_diag.vsd

Figure 4 **BIS measurement system block diagram**

2.3.1 Digital Signal Converter, DSC

The digital signal converter, DSC, receives, amplifies and digitizes patient EEG signals. It is placed close to the patient's head where the EEG signal is less subject to interference from other medical equipment. The digital signal converter is connected to the module with a 3.6m long shielded cable and to the BIS sensor with a 1.2m long patient interface cable, see Measurement setup. For BIS Sensor related documentation refer to BIS documentation by Aspect, Inc.

CAUTION Do not autoclave the DSC. Do not open it for any reason.

WARNING **When using the electrosurgery unit, ensure proper contact of the ESU return electrode to the patient to avoid burns at monitor measurement sites. Also ensure that the ESU return electrode is near the operating area.**

WARNING **Radiated field strengths above 1V/m may cause erroneous measurements at various frequencies. Do not use electrical radiating equipment close to the DSC.**

2.3.2 BIS Module

Aspect BIS Engine

The BIS Module provides Bispectral index values to the monitor. The BIS Engine processes the digital signal from DSC and outputs the BIS index and other supporting parameters through an asynchronous serial connection. The BIS Engine outputs the BIS Index, raw EEG, EMG, Signal Quality Index (SQI), Suppression Ratio (SR) and electrode impedances. The BIS Engine software includes Aspects' proprietary algorithm for BIS calculation.

BIS interfacing board

The BIS interfacing board supplies data from the BIS Engine to the monitor via a module bus. In addition, the module accepts commands from the monitor via the module bus. The module also provides supply voltages and all the required control signals to the BIS Engine and DSC.

The controller H8 has on-chip RAM and FLASH ROM, external SRAM and EEPROM.

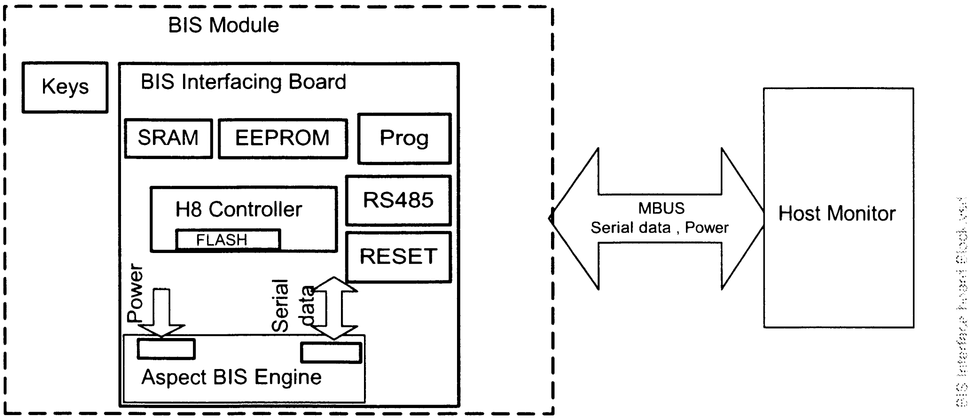
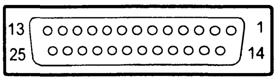

BIS Module
Keys
BIS Interfacing Board
SRAM
EEPROM
Prog
H8 Controller
FLASH
RS485
RESET
Power
Serial data
Aspect BIS Engine
MBUS
Serial data , Power
Host Monitor

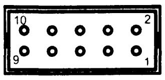
Figure 5 Block diagram of setup

2.4 Connectors and signals

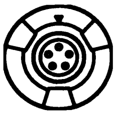
2.4.1 Module bus connector

Module bus connector (X1)	**Pin No.**	**Name**	**Description**
	1	Reset_ RS485	Module Bus Reset +
	8	Nreset_ RS485	Module Bus Reset -
	6	Data_ RS485	Module Bus Data +
	5	Ndata_ RS485	Module Bus Data -
	3	+15VD	+15V Supply voltage
	7	GND	Ground
	13	GND	Ground
	15	GND	Ground
	22	RS232_TXD	BIS-Engine SW update, data out, no monitor use
	23	RS232_RXD	BIS-Engine SW update, data in, no monitor use
	24	+5,1V	+5V Supply voltage
	25	+5,1V	+5V Supply voltage
	Other	NC	Not Connected

2.4.2 H8 programming connector

Connector	**Pin No.**	**Name**	**Description**
	1	GND	Ground
	2	PRG_FB	Program feedback
	3	TxD	Data output to programmer
	4	RxD	Data input from programmer
	5	/RESET	RESET input from programmer
	6	VDD	Power input from programmer
	7	PRG_VCC	Programming voltage from programmer
	8	MODE.2/BOOT	Control input from programmer
	9	PCFB	Programmer Connector feedback / GND
	10	CODE_RES	Coding resistor output to programmer

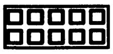
2.4.3 DSC and BIS Engine connectors

	**Pin No. Redel**	**Name**	**Pin No. Samtec**	**Description**	
	1	DSC_OUTA	2	Power out A	
	2	DSC_OUTB	4	Power out B	
	3	DSC_IN	6	Data input	
	4	DGND	7,8,9,10	Ground	
	5	Chassis Ground	1,3,5,	Ground	

2.4.4 BIS Engine power connector

	Pin No.	**Name**	**Description**
	1, 2	+12V	+12V Power output for BE
	5,6,7,8	+5V	+5V Power output for BE
	3,4,9,10	GND	Ground

2.4.5 BIS Engine serial data connector

	**Pin No.**	**Name**	**Description**
	1	RS232_RXD	Data input to BE
	2	TTL_RXD	Data input to BE
	3	RS232_TXD	Data output from BE
	4	TTL_TXD	Data output from BE
	5	NC	Not Connected
	6	NC	Not Connected
	7	RS232_RESET	Reset input to BE
	8	/TTL_RESET	/RESET input to BE
	9	GND	Ground
	10	/USE_TTL	TTL/RS232 selection input to BE

3 Service procedures

3.1 General service information

The field service of the E-BIS is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The BIS Simulator (order No. 900509) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
BIS Simulator or BIS Sensor simulator	900509 900508	
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts
   Check that:
   - screws are tightened properly
   - cables are connected properly
   - there are no loose objects inside the module

   ✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   Reattach the module box.

   ✍

3. Check the external parts of DSC

   - the cover and the panel stickers are intact
   - cables and their connections are intact

   Do not connect DSC to the module yet.

   ✍

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the BIS measurement is shown:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field1 - BIS EEG***
Others - ***BIS - Scale - 100uV***
Others - ***BIS - Smoothing Rate 15s***

4. Installation

   Plug in the module. Check that it goes in smoothly and engages properly.

   ✍

5. Recognition of module

   Check that the module is recognized, i.e. the BIS header with related information appears in the chosen waveform field and 'Cable off' message is shown in the field.

   ✍

6. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Record the information regarding the module software of E-BIS by selecting ***Scroll vers*** and turning the ComWheel.

NOTE: DSC related data will appear only when the DSC is connected for the first time after start-up.

✍

7. Recognition of DSC

   Connect the PIC+ cable to the DSC.

   Connect the DSC to the module.

   - Check that the DSC is recognized (DSC related data appears on the page)
   - Check that 'No sensor' appears in the selected waveform field.

8. Communication and memories of module

   Enter the BIS module service menu:

   Parameters - More... - BIS

   Check that the Mod Mon Time-outs, Mon Mod Bad checksums, Mod Mon Bad Checksums, Bad Checksums from BIS values in the module view are not increasing faster than by 5 per second. Check that the memories of the module have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

9. Membrane keys

   Check the **BIS** and **Check Sensor** membrane keys of the module. Stay in the module view and press each key for at least one second and check that the key being pressed is identified, i.e. the corresponding 'PRESSED' text appears in the service menu.

10. Message from BE

    Check that Messages from BE are increasing steadily.

11. Sensor ID

    Go to the Sensor page.

    Check that:

    - no sensor is identified
    - mains frequency is set correctly
    - check that BE power-up test, DSC selftest Ch1 and DSC selftest Ch2 all show PASS
    - (if not, go to BIS Setup page, perform DSC Test and check the results again)

12. Sensor check

    Connect the BIS simulator to the PIC+ cable. See that 'Checking sensor' text and an image appear. Wait for a while and check that all sensors show PASS. Check that the Sensor type shows Demo Sensor.

13. Checks with simulator

    Check that the BIS, SQI and SR values are between 0...1000, and the EMG value between 0...10000.

NOTE: If Sensor simulator 900508 is used, the values can be out of the given range.

14. BIS Engine errors

    Go to the Module page

    Check that no BIS Engine errors appear.

15. Sensor check

    Perform sensor check by pressing **Check Sensor** and verify that the sensor shows PASS.

16. Electrical safety check

    Perform an electrical safety check and a leakage current test.

17. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

18. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

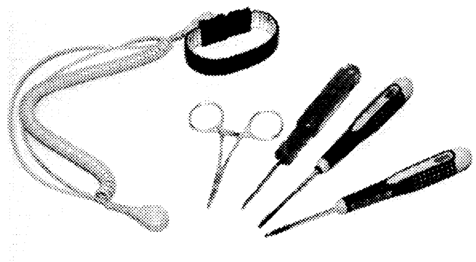
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the E-BIS module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the BIS Engine board by removing the four screws located at the corners of the board and disconnecting the front panel connector cable.
4. Detach the interface board by removing the two screws located near the front panel frame, disconnect the cable and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
No BIS waveforms on screen.	BIS waveforms not selected on screen.	Press **Monitor Setup** key and select BIS waveforms on the screen.
Sensor impedance check is not available on menus.	Sensor is not connected to the DSC or DSC is not connected to the module.	Connect the sensor and the DSC.
Sensor impedance check fails.	Sensor poorly attached.	Attach the sensor by following the sensor instructions.

4.2 Messages

The messages below appear in the BIS digit field (DF), BIS waveform field (WF) or the message field (MF) at the upper section of the Datex-Ohmeda S/5 patient monitor display.

Message	**Location**	**Cause**	**What to do**
Cable off BIS cable off	DF MF	DSC cable is not connected to the module.	Connect the DSC to the module.
No Sensor No BIS Sensor	DF MF	Sensor is not connected to PIC+ cable or PIC+ cable is not connected to the DSC.	Connect the sensor to the PIC+ cable . Connect the PIC+ cable to the DSC. Replace sensor and then PIC+ cable.
Incompatible sensor	DF	Sensor is not recognized. Sensor is not a BIS sensor.	Connect correct type of sensor. Make sure PIC connector is clean and dry
Incompatible DSC	DF	Current module hw/sw is incompatible with this DSC E.g. DSC-2	Connect correct type of DSC.
Sensor check failed BIS sensor check failed	DF MF	Sensor check failed, one or more of the electrode impedances exceeds the threshold.	Reattach the sensor to the patient by following the sensor instructions. Replace the sensor. Check PIC+ cable and then DSC.
Poor signal	DF	Artifacts, or the amount of EMG activity prevents calculating BIS, data excluded. SQI < 50	Check the sensor, then the PIC cable. Reattach the sensor to the patient by following the sensor instructions
Checking sensor		Sensor check in progress. Can be either the initial sensor check, manual check or the periodic check.	Wait until the check has been performed

Message	**Location**	**Cause**	**What to do**
'Checking sensor' message stays more than 2 min.	DF	Sensor check fails, the sensor is not attached to the patient while connected to the PIC+ cable.	Attach the sensor to the patient and press the Check Sensor button on the module front panel.
Automatic check off	DF	Continuous sensor checking has been turned off.	Turn the check on from the BIS menu.
Replace Sensor	DF	The sensor has passed its use by date. The sensor has been used for 24h.	Replace with a new sensor.
High BIS impedance	DF	Sensor is not attached properly to the patient	Check the cable connections. Reattach the sensor to the patient by following the sensor instructions.
Artifact	DF	Non-EEG data such as EMG, eye blinks or shivering present.	Wait for good data.
Module error	DF	BIS Engine failure for more information see service page description.	Replace the BIS Engine.
DSC Error	DF MF	The DSC is not communicating or operating properly. This may occur during the use of electrocautery device. For more information see service page description.	Replace the DSC. If the message persists, the BIS Engine may require service.
Demo data	MF	BIS simulator is connected.	Disconnect the BIS simulator.

4.3 Troubleshooting flowchart

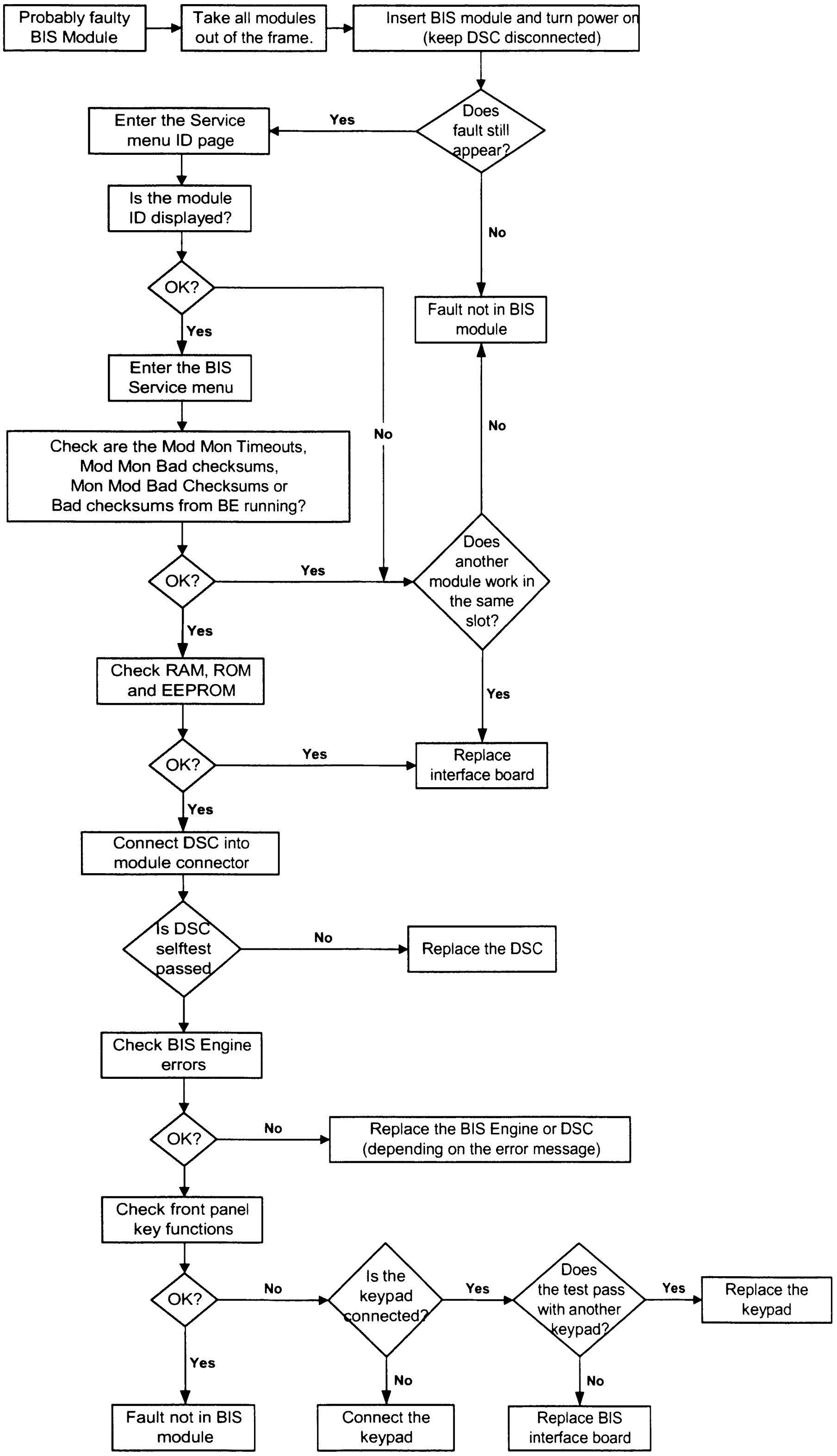

Probably faulty BIS Module
Take all modules out of the frame.
Insert BIS module and turn power on (keep DSC disconnected)
Does fault still appear?
Yes
Enter the Service menu ID page
No
Is the module ID displayed?
OK?
Yes
Fault not in BIS module
Enter the BIS Service menu
No
No
Check are the Mod Mon Timeouts, Mod Mon Bad checksums, Mon Mod Bad Checksums or Bad checksums from BE running?
OK?
Yes
Does another module work in the same slot?
Yes
Check RAM, ROM and EEPROM
Yes
OK?
Yes
Replace interface board
Yes
Connect DSC into module connector
Is DSC selftest passed
No
Replace the DSC
Check BIS Engine errors
OK?
No
Replace the BIS Engine or DSC (depending on the error message)
Check front panel key functions
OK?
No
Is the keypad connected?
Yes
Does the test pass with another keypad?
Yes
Replace the keypad
Yes
No
No
Fault not in BIS module
Connect the keypad
Replace BIS interface board

Figure 6 **BIS module troubleshooting flowchart**

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} BIS Module, E-BIS.

APPENDIX A Service check form, BIS Module, E-BIS (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. Check the external parts of DSC	☐	☐	☐				
Notes							
Functional inspection							
4. Installation	☐	☐	☐	5. Recognition of module	☐	☐	☐
6. Module software	E-BIS						
7. Recognition of DSC	☐	☐	☐	8. Communication and memories of module	☐	☐	☐
9. Membrane keys	☐	☐	☐	10. Message from BE	☐	☐	☐
11. Sensor ID	☐	☐	☐	12. Sensor check	☐	☐	☐

13. Checks with simulator	Measured value	Allowed range
BIS		0...1000
SQI		0...1000
SR		0...100
EMG		0...10000

	OK	N.A.	Fail		OK	N.A.	Fail
14. BIS Engine errors	☐	☐	☐	15. Sensor check	☐	☐	☐
16. Electrical safety check	☐	☐	☐	17. Functioning after electrical safety check	☐	☐	☐
18. Final cleaning	☐	☐	☐				

Notes

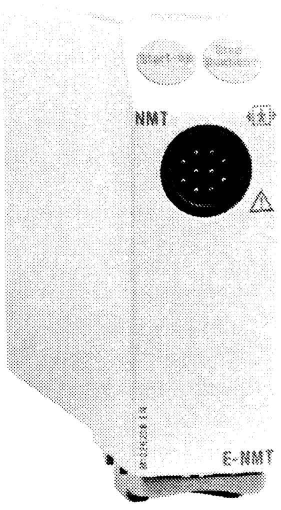
Used spare parts			

Signature

Datex-Ohmeda

S/5™ NeuroMuscular Transmission Module, E-NMT (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027834
June, 2005

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Appendix A: Service check form, NeuroMuscular Transmission Module, E-NMT (Rev. 00) A-1

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Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the NeuroMuscular Transmission Module, E-NMT. The E-NMT module is a single width plug-in module designed for use with the Datex-Ohmeda Anesthesia and Compact Anesthesia Monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The module contains peripheral nerve stimulation and response measurement, which supports electromyography EMG. The module can also be used as a nerve locator for regional nerve blocking with a regional block cable. However, in this case there is no response measurement.

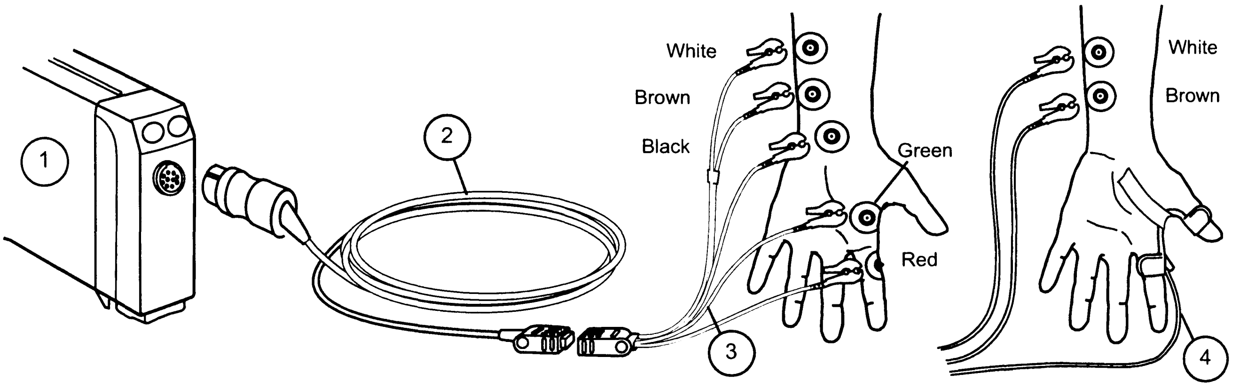


Figure 1 NMT Setup

(1) Module measuring NMT
(2) NMT sensor cable
(3) ElectroSensor
(4) MechanoSensor

Monitor software compatibility

The E-NMT requires monitor software S-xxx95 or later.

From the M-NMT rev.01 onwards, NMT modules have contained a memory for storing stimulus current and reference response data. The memory function requires monitor software S-xxx97 or later.

Equipment safety symbols

⚠ - When displayed on the E-NMT module, indicates the following warnings:

* Do not place the NMT stimulating electrodes on the patient's chest.
* Always stop the NMT measurement before handling the stimulating electrodes.
* Never subject a patient with an implanted electronic device to electrical stimulation without consulting a medical specialist first.

1 Specifications

1.1 General specifications

Module size, W × D × H	37 x 186 x 112 mm / 1.5 x 7.3 x 4.4 in
Module weight	0.35 kg /0.8 lb.
Power consumption	3.3 W

1.2 Technical specifications

1.2.1 NMT

Stimulation modes	Train of four (TOF) Double burst (3.3) (DBS) Single twitch (ST) 50 Hz tetanic + post tetanic count (PTC)
Measurement intervals for TOF / DBS	Manual; 10 s, 12 s, 15 s, 20 s, 1 min, 5 min, 15 min in AM and CAM Manual; 20 s, 1 min, 5 min, 15 min, 30 min, 60 min, 120 min in CCM and CCCM
Measurement intervals for ST	Manual; 1 s, 10 s, 20 s

1.2.2 Stimulator

Stimulus pulse	Square wave, constant current
Pulse width	100, 200 or 300 μs
Stimulus current range	supramax 10...70 mA, manual 10...70 mA with 5 mA steps
Stimulus current accuracy	10% or ±3 mA
Max. load	3 kΩ
Max. voltage	300 V

1.2.3 Regional block mode

Stimulation modes	Single twitch
Intervals	1 s, 2 s, 3 s
Stimulus pulse	Square wave, constant current
Pulse width	40 μs
Stimulus current range	0...5.0 mA with 0.1 mA steps
Stimulus current accuracy	20% or ±0.3 mA

2 Functional description

2.1 Measurement principle

2.1.1 Nerve stimulation

There are three stimulus modes in the NeuroMuscular Transmission Module: Train of Four (TOF), Double Burst 3,3 (DBS) and Single Twitch (ST).

In the Train of Four stimulus mode, four stimulation pulses are generated at 0.5 second intervals. The response is measured after each stimulus and the ratio of the fourth and first response of the TOF sequence is calculated (TOF%).

NOTE: If the first response does not exceed a certain signal level, TOF% is not calculated due to poor accuracy.

Double burst (3,3) stimulation includes two bursts with a 750 ms interval. Both bursts consist of three pulses separated by 20 ms intervals. The responses of both bursts are measured, and the ratio of the second and first response is calculated (DBS%). EMG responses are measured immediately after the first stimulus pulse of both bursts.

In Single Twitch stimulation, one stimulation pulse is generated. The response is measured after the stimulus. In order to prevent decurarization of the stimulated area, the measurement is automatically stopped after 5 minutes stimulation in 1 sec. cycle time.

Tetanic/PTC

Tetanic/PTC (Post Tetanic Count) can measure deeper relaxation than TOF. The tetanic stimulation is produced when Start is chosen under Tetanic/PTC. The length of stimulation is 5 seconds. The stimulation generates pulses with a frequency of 50 Hz and with a selected pulse width and current. After tetanic stimulation and a three second delay, Single Twitch stimulation is produced to detect the post tetanic count (PTC). PTC describes the number of responses detected after tetanic stimulation. If there is no response, the measurement will be stopped. If responses will not fade away, a maximum of 20 responses will be calculated. If more can be detected, the PTC value is displayed only as '> 20' and measurement will be stopped. If the TOF, DBS or ST measurement cycle was on when tetanic stimulation started, the cycle will continue after the PTC. After completing the PTC measurement during 1 minute TOF, DBS or another PTC measurement is not possible. This is to avoid erroneous readings due to post tetanic potentiation.

2.1.2 Response

Before each stimulation, the sequence offset, noise and threshold for the response detection are measured. Offset is a baseline of the noise measurement. Noise is calculated by the same algorithm as the response signal itself. The response detection threshold is calculated based on the noise, and if the response is not greater than the threshold then it is interpreted as no response.

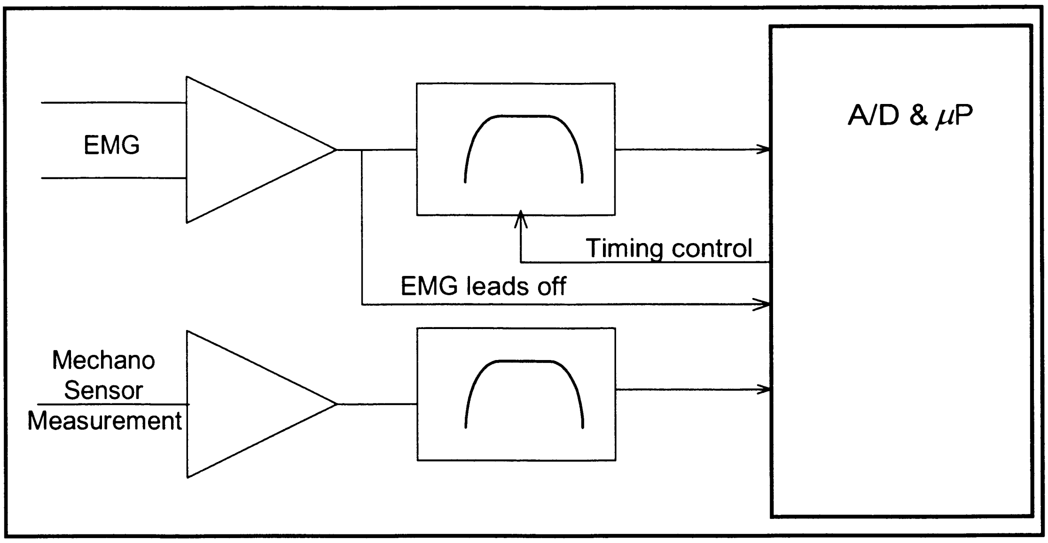


Figure 2 **Principle of response measurement**

EMG measurement

The EMG response is measured as integrated muscle activity. The EMG measurement starts 3 ms after the stimulation and lasts 15 ms. The 3 ms delay helps to prevent the effect of stimulation artifact.

Mechano sensor measurement

Response is measured as movement of the thumb, which is the area of positive signal.

2.1.3 Regional block

A regional block cable can be used as a nerve locator in local anesthesia. A maximum current of 5.0 mA is given every, every other or every 3rd second. The response measurement is ocular.

2.2 Main components

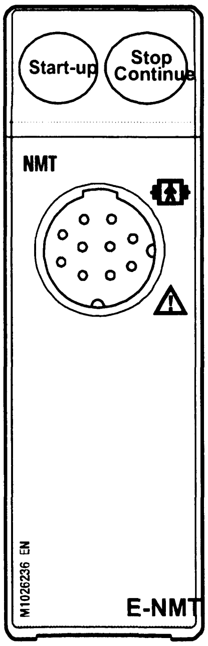


Figure 3 Front panel of NeuroMuscular Transmission Module, E-NMT

Start-up	starts the search of supramaximal current and reference level and proceeds with the selected measurement cycle.
Stop/Continue	interrupts monitoring and restarts monitoring of the same patient.

2.2.1 NMT board

The NMT board consists of the following functional sections:

- constant current stimulator
- measuring electronics for the EMG signals
- microprocessor for the stimulation and measuring control, and for counting the measuring results
- serial communication

The serial bus speed is 500 kbps and the bus itself is half duplex, i.e. data can be transferred in both directions but only one way at a time.

Serial communication

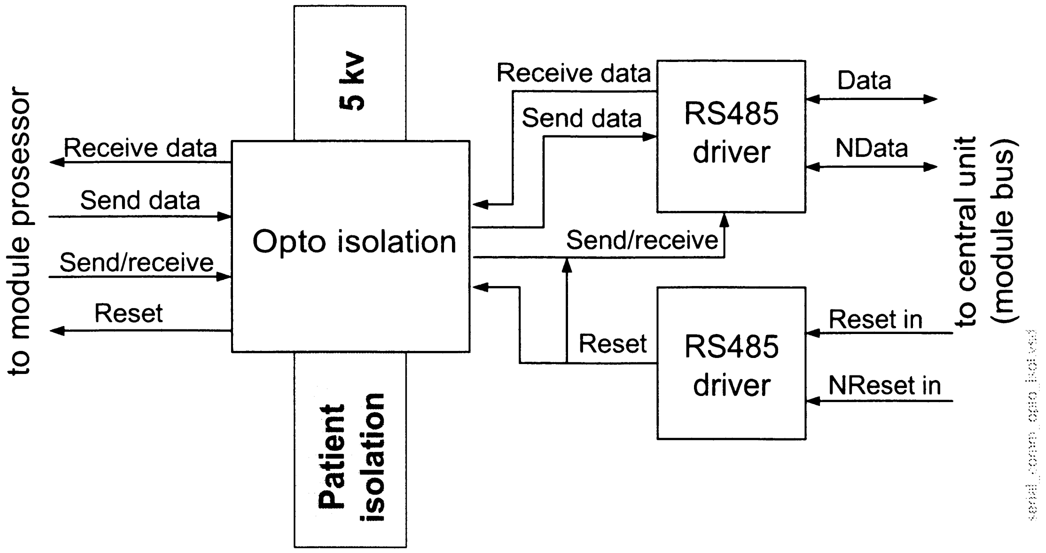

to module prosessor
Receive data
Send data
Send/receive
Reset
5 kv
Opto isolation
Patient isolation
Receive data
Send data
Send/receive
Reset
RS485 driver
RS485 driver
Data
NData
Reset in
NReset in
to central unit (module bus)

Figure 4 **Serial communication and opto isolation**

Stimulator

The constant current stimulator generates pulses whose amplitude is independent of the load. The main components of the stimulator are a transformer, capacitor and transistor. The transformer produces a high voltage which charges the capacitor and the transistor adjusts the pulse width and amplitude of the current.

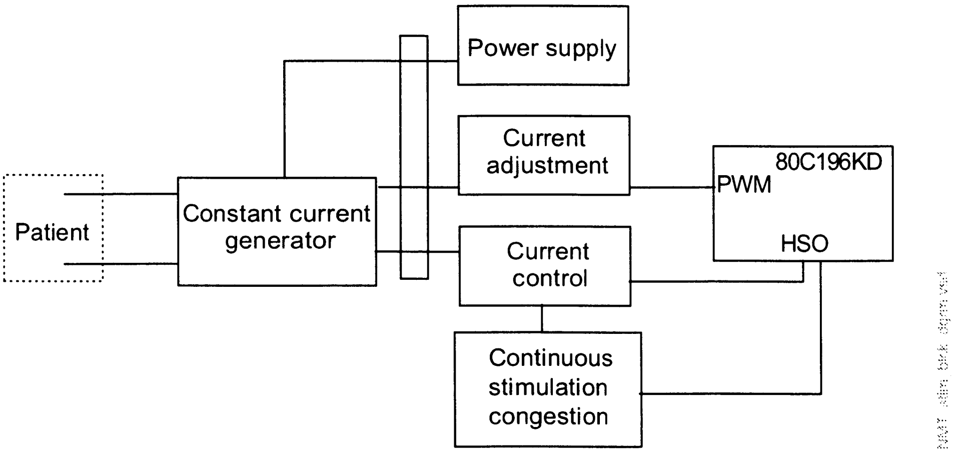
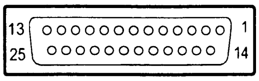

Power supply
Current adjustment
80C196KD
PWM
HSO
Patient
Constant current generator
Current control
Continuous stimulation congestion

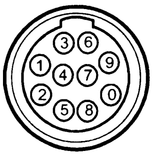
Figure 5 **Stimulator block diagram**

2.3 Connectors and signals

2.3.1 Module bus connector

Module bus connector (X1)	Pin No.	I/O	Signal
	1	I	RESET_RS485
	2	I	-15 VDC
	3	I	+15 VDIRTY
	4	I	+15 VDC
	5	I/O	-DATA_RS485
	6	I/O	DATA_RS485
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	I	CTSB
	10	O	RTSB
	11	I	RXDB
	12	O	TXDB
	13	-	Ground & Shield
	14	I	+32 VDIRTY
	15	I	GroundDIRTY
	16	I	CTSC
	17	O	RTSC
	18	I	RXDC
	19	O	TXDC
	20	-	ON/STANDBY
	21	-	PWM_ECG
	22	-	RXDD_RS232
	23	-	TXDD_RS232
	24	I	+5 VDC
	25	I	+5 VDC

2.3.2 NMT connector (NMT)

Front panel connector	**Pin No.**	**Signal**
	1	EMG Signal +
	2	EMG Signal -
	3	Not Used
	4	Stimulus +
	5	Stimulus -
	6	Ground
	8	Sensor Identification
	9	+5 V
	10	Mechanical Signal

3 Service procedures

3.1 General service information

The field service of the NeuroMuscular Transmission Module, E-NMT, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

The NMT Simulator (order code 871251) is recommended for functional checks.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
NMT simulator	871251	
E-NMT ElectroSensor		
E-NMT MechanoSensor		
E-NMT Sensor Cable		
3 kΩ resistor		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly

- the EMC cover is attached properly
- there are no loose objects inside the module

✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - connectors are intact and attached properly
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that information regarding the NMT measurement is shown, for example:

Monitor Setup - ***Screen 1 Setup*** - ***Digit Fields*** - ***Field 4*** - ***NMT***

Preset the NMT measurement settings:

Others - ***NMT*** - ***Stimulus Mode*** - ***TOF***
Set Cycle Time - 10 sec.
NMT Setup - Current - S(70 mA)
Pulse Width - 200 mS
Stim. Beep Volume - 2

3. Installation

   Plug in the module. Check that it goes in smoothly and locks up properly

   ✍

4. Recognition

   Check that the module is recognized, i.e. the NMT header with related information appear in the chosen digit field.

   ✍

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service (password 16-4-34)*** - ***Service (password 26-23-8)***

   Take down the information regarding the NMT software by selecting ***Scroll vers*** and turning the ComWheel.

   ✍

6. Communication and memories

   Enter the NMT module service menu:

   Parameters - NMT

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the module's memories have passed the internal memory test, i.e. RAM, ROM and EEPROM all state OK.

   ✍

7. Membrane keys

   Check the front panel **START-UP** and **STOP/CONTINUE** membrane keys.

   Press each key for at least one second and check that the key being pressed is identified, i.e. the color under the corresponding text on the menu turns blue.

   ✍

8. ElectroSensor recognition

   Check that the message 'Cable off' is shown in the digit field and that Cable in the Service Data field states OFF.

   Plug the E-NMT Sensor Cable with the E-NMT ElectroSensor into the front panel connector NMT. Check that the message in the digit field changes to 'Measurement OFF' and Cable in the Service Data field states EMG and ELECTR. OFF.

   ✍

9. Stimulus current test

   Perform the stimulus current test.

   Connect a 3 kΩ resistor between the ElectroSensor's stimulus electrode leads (brown and white).

   Start the test by selecting ***START CURR. TEST*** on the service menu and pressing the ComWheel. Check that the test was successful with all three test currents, i.e. the ***Current test (mA):*** in the Service Data field states 30 OK, 50 OK and 70 OK.

   ✍

   Connect the E-NMT ElectroSensor leads to the NMT simulator. Set the switch on the simulator to Fade off and turn the knob to max. Check that Cable in the Service Data field now states only EMG.

10. Supramaximal current

    Start NMT measurement (TOF) by pressing the **START-UP** key on the module.

    When the message 'Supramax search' changes to 'Setting reference' in the digit field, check that the supramaximal current detected is less than 70 mA, i.e. the Current set value in the Service Data field is less than 700.

    ✍

11. TOF measurement with NMT simulator

    Check that the module gives four successive stimulus pulses with 10 second intervals. A small asterisk (\) should be shown in the digit field during each of the stimulus pulses and simultaneous sound signals should be heard from the loudspeaker.

    Check that in the Service Data field the values for T1%, T2%, T3%, T4% and Ratio% are all within 950-1059.

    Check also that in the digit field the TOF% value is within 95-105, Count is 4 and T1% is within 95-105.

12. Noise

    Check that the Noise value in the Service Data field stays under 100.

13. Stimulus pulse width

    Change the stimulus pulse width to 100 μs through the NMT service menu:

    NMT Setup - Pulse Width - 100 mS

    Check that the TOF% value is still within 95-105, Count is 4 and T1% is within 95-105 in the digit field.

    Check the same parameters with a stimulus pulse width of 300 s.

14. No response

    Turn the knob on the NMT simulator to 0.

    Check that in the Service Data field the values for T1%, T2%, T3%, T4% turn to 0 and the Ratio% states - - -. In the digit field TOF% should also state - - -, and Count and T1% should show 0.

    Turn the NMT simulator knob back to max.

15. DBS measurement with NMT simulator

    Change the stimulus mode to Double Burst Stimulation (DBS) through the service menu:

    NMT Setup - Stimulus Mode - DBS

    Check that the module now gives only two stimulus pulses with a 10 seconds interval.

    Check that in the Service Data field the values for T1%, T2%, and Ratio% are still within 950-1059. In the digit field the DBS% value should be within 95-105, Count is 2 and T1% is within 95-105.

16. ST measurement with NMT simulator

    Change the stimulus mode to Single Twitch Stimulation (ST):

    NMT Setup - Stimulus Mode - ST

Check that the module starts to give only one stimulus pulse with a 1 second interval. Note the time when the ST stimulation started.

Check that in the Service Data field the value for T1% is within 950-1059. In the digit field, the Count value should be 1 and T1% within 95-105.

Let the monitor continue to give single twitch stimulation.

✍

17. Automatic measurement off

    Check that the NMT measurement stops and the message 'Measurement OFF' appears in the digit field for NMT five minutes after the start of the ST stimulation.

    ✍

18. MechanoSensor recognition

    Replace the E-NMT ElectroSensor with the E-NMT MechanoSensor and check that Cable in the Service Data field states PIEZO.

    ✍

19. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

20. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

21. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

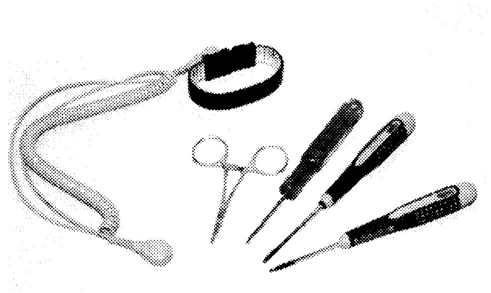
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.4 To disassemble the module

To disassemble the NeuroMuscular Transmission Module, E-NMT (see the exploded view of the NMT Module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Detach the NMT board by removing the two screws located near the front panel frame, disconnect the cables and pull out the front panel frame.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

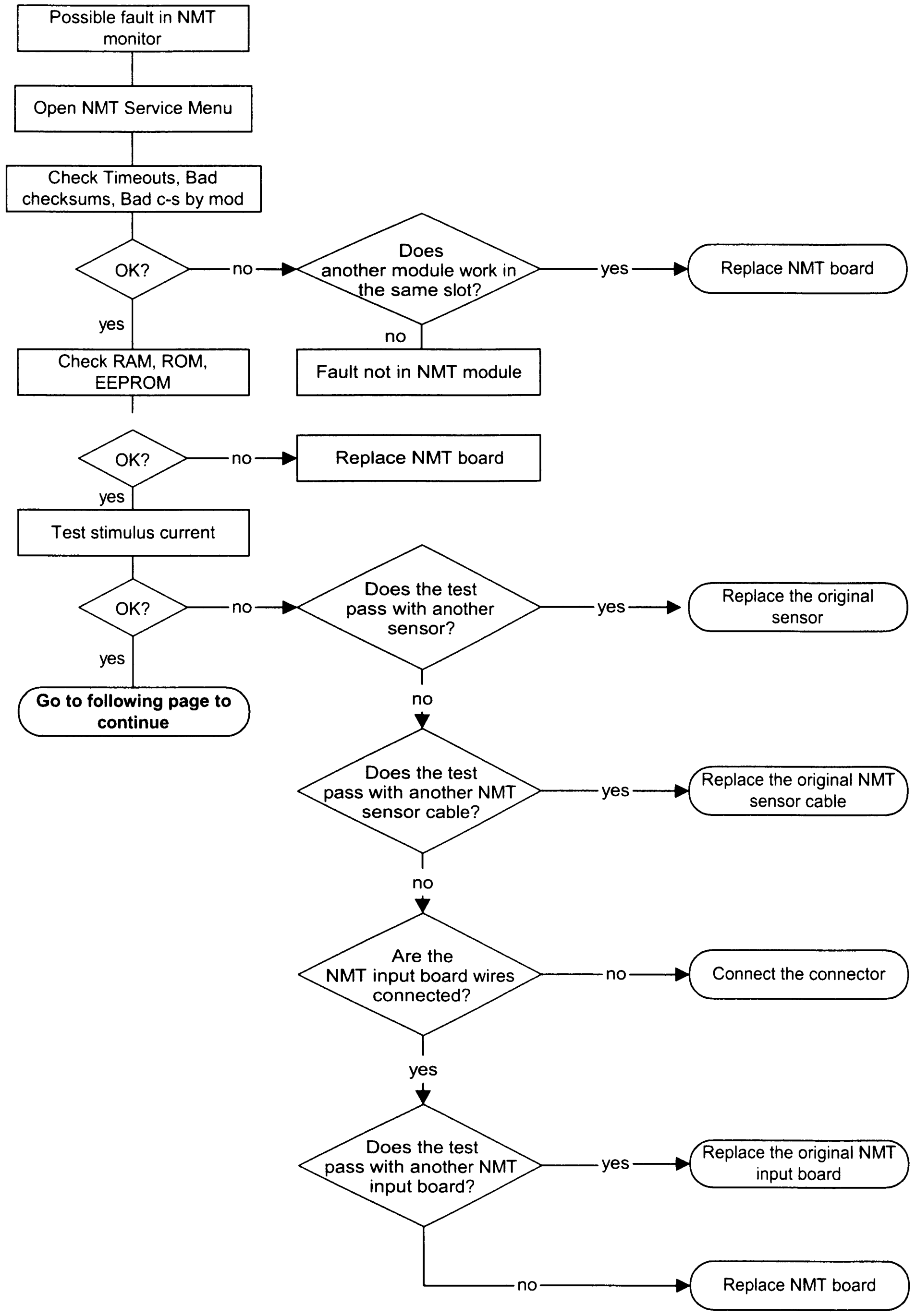
Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
Check the stimulus electrodes. EMG electrode off.	Loose electrodes or loose stimulus clip.	Change or attach the electrodes or clip.
Supramax. not found.	Loose electrodes or loose stimulus clip. Stimulus electrodes attached to wrong place. Patient is relaxated.	Change or attach the electrodes or clip. Change the place of the stimulus electrode.
Response too weak.	Loose stimulus electrodes. Measuring electrodes attached to wrong place. Patient is relaxated.	Change or attach the electrodes. Change the place of the meas. electrodes.
Ref. not stable.	Patient is relaxated. Movement artifact.	

4.2 Troubleshooting flowchart


Possible fault in NMT monitor
Open NMT Service Menu
Check Timeouts, Bad checksums, Bad c-s by mod
OK?
no
Does another module work in the same slot?
yes
Replace NMT board
no
Fault not in NMT module
yes
Check RAM, ROM, EEPROM
OK?
no
Replace NMT board
yes
Test stimulus current
OK?
no
Does the test pass with another sensor?
yes
Replace the original sensor
yes
Go to following page to continue
no
Does the test pass with another NMT sensor cable?
yes
Replace the original NMT sensor cable
no
Are the NMT input board wires connected?
no
Connect the connector
yes
Does the test pass with another NMT input board?
yes
Replace the original NMT input board
no
Replace NMT board

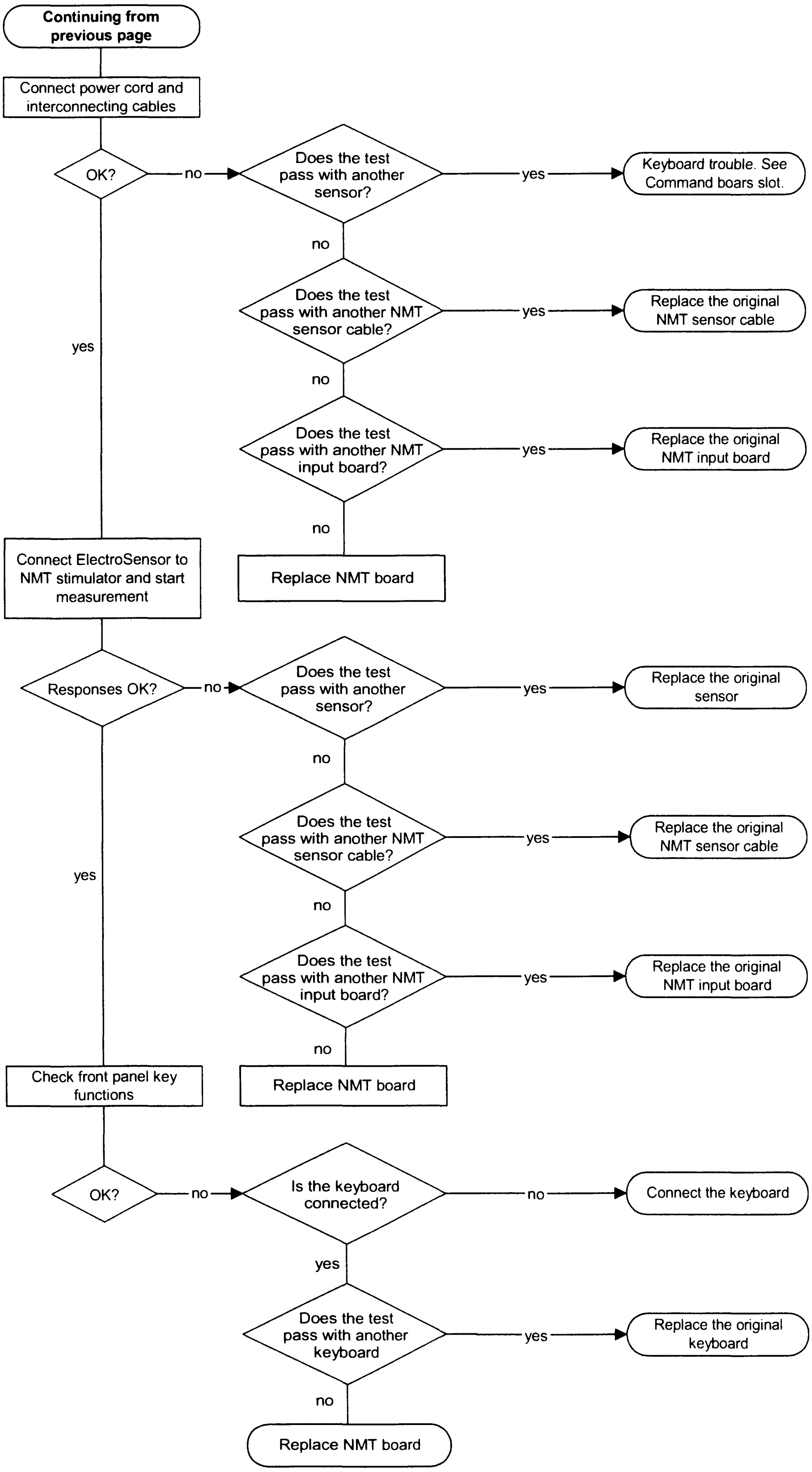

Continuing from previous page
Connect power cord and interconnecting cables
OK?
no
Does the test pass with another sensor?
yes
Keyboard trouble. See Command boars slot.
no
Does the test pass with another NMT sensor cable?
yes
Replace the original NMT sensor cable
no
Does the test pass with another NMT input board?
yes
Replace the original NMT input board
no
Replace NMT board
yes
Connect ElectroSensor to NMT stimulator and start measurement
Responses OK?
no
Does the test pass with another sensor?
yes
Replace the original sensor
no
Does the test pass with another NMT sensor cable?
yes
Replace the original NMT sensor cable
no
Does the test pass with another NMT input board?
yes
Replace the original NMT input board
no
Replace NMT board
yes
Check front panel key functions
OK?
no
Is the keyboard connected?
no
Connect the keyboard
yes
Does the test pass with another keyboard
yes
Replace the original keyboard
no
Replace NMT board

Figure 6 Module troubleshooting flowchart

5 Earlier revisions

There are no earlier revisions of the S/5^{TM} NeuroMuscular Transmission Module, E-NMT.

APPENDIX A Service check form, NeuroMuscular Transmission Module, E-NMT (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐	4. Recognition	☐	☐	☐
5. Module software	NMT						
6. Communication and memories	☐	☐	☐	7. Membrane keys	☐	☐	☐
8. ElectroSensor recognition	☐	☐	☐	9. Stimulus current test	☐	☐	☐

10. Supramaximal current		<70 mA
11. TOF measurement with NMT simulator	Measured value	Allowed range
T1%		950...1059
T2%		950...1059
T3%		950...1059
T4%		950...1059
Ratio%		950...1059
TOF%		95...105
Count		4
T1%		95...105
12. Noise		<100

13. Stimulus pulse width	100	300	Allowed range
TOF%			95...105
Count			4
T1%			95...105
	OK **N.A.** **Fail**		
14. No response	☐ ☐ ☐		

15. DBS measurement with NMT simulator	Measured value	Allowed range
T1%		950...1059
T2%		950...1059
Ratio%		950...1059
DBS%		95...105
Count		2
T1%		95...105
16. ST measurement with NMT simulator	Measured value	Allowed range
T1%		950...1059
Count		1
T1%		95...105

	OK **N.A.** **Fail**		**OK** **N.A.** **Fail**
17. Automatic measurement off	☐ ☐ ☐	18. MechanoSensor recognition	☐ ☐ ☐
19. Electrical safety check	☐ ☐ ☐	20. Functioning after electrical safety check	☐ ☐ ☐
21. Final cleaning	☐ ☐ ☐		

Notes

Used spare parts			

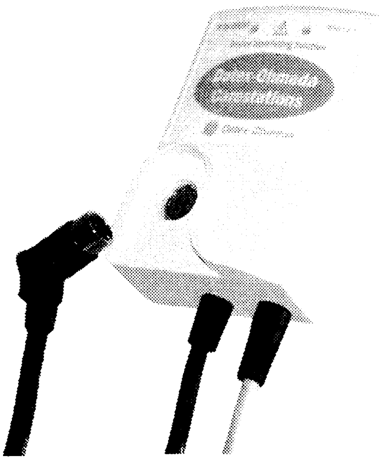
Signature

Datex-Ohmeda

S/5™ Device Interfacing Solution, N-DISxxx (Rev. 00)

S/5™ Device Interfacing Solution, N-DISxxx (Rev. 01)

Technical Reference Manual



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027835
June, 2005

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Appendix A: Service check form,
Device Interfacing Solution, N-DISxxx (Rev. 00 and Rev. 01) **A-1**

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Introduction

This "Technical Reference Manual" slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Device Interfacing Solution, N-DISxxx. Later in this manual modules may be referred to without S/5 for simplicity.

Please also refer to the "Installation Guide" accompanying each module.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The purpose of the Device Interfacing Solution is to produce a data connection between an external bedside device and a Datex-Ohmeda modular monitor.

The N-DISxxx is a new interfacing solution and works beside the previous interface solutions, E-INT, M-INT and B-INT that are still available.

Up to 10 devices can be connected simultaneously via device specific N-DISxxx modules. No Device Interfacing Solution is called N-DISxxx, but the xxx are replaced with a device specific ending like N-DISQVUE and N-DISOPT.

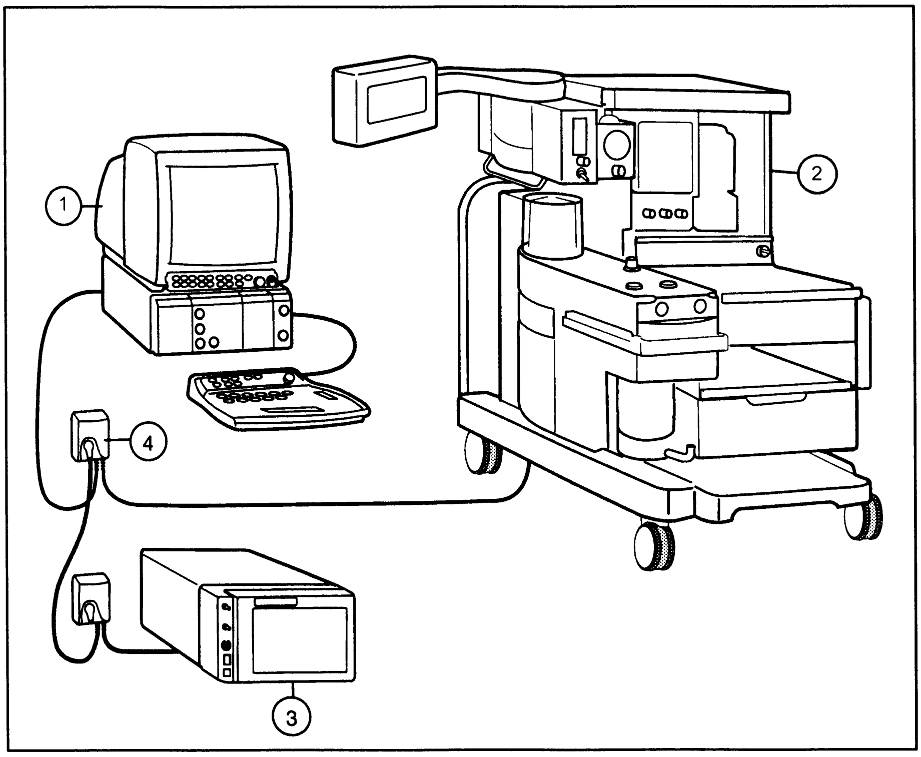


Figure 1 An example of interfacing external devices with Device Interfacing Solution

(1) Datex-Ohmeda S/5 Anesthesia Monitor (with software L-ANE01(A) or later).

(2) Aestiva3000 Anesthesia machine.

(3) RGM monitor.

(4) DIS module (max. 10 pcs)

Monitor compatibility

The Device Interfacing Solution requires the following monitor software versions:

- S/5 Anesthesia Monitor with software version L-ANE01 or later.
- S/5 Critical Care Monitor with software version L-ICU01 or later
- S/5 Compact Anesthesia Monitor with software version L-CANE02 or later.
- S/5 Compact Critical Care Monitor with software version L-CICU02 or later

The Device Interfacing Solution requires B-UPI4(NET) or later.

1 Specifications

1.1 Environmental specification

Operating temperature	+10...+35 °C (50...95 °F)
Storage and transport temperature	-10...+50 °C (14...122 °F)
Relative humidity	10...90% (non condensing)
Atmospheric pressure	660...1060 hPa (66...106 kPa/660...1060 mbar/500...800 mmHg)

1.1.1 Protection against ingress of liquids

According to IEC/EN 60592 class IPX 1.

The DIS module must always be used in a vertical position to prevent water from entering the module.

1.2 Technical specifications

1.2.1 General

Max 10 DIS modules or 10 m (33 ft) cable length.

Module

Size (W × D × H)	60 × 27 × 85 mm/2.4 × 1.1 × 3.4 in
Weight	0.1 kg/0.2 lb.

Bus cables

8 pin Hirose HR12/HR212 connector

Material	black PVC
Length/Weight	1 m/47 g (39 in/3.3 ft./0.104 lb.) 2 m/85 g (79 in/6.6 ft./0.187 lb.) 6 m/220 g (236 in/19.7 ft./0.485 lb.)

Device cables

Depends on device.

Material	elastollan
Length	0.5...1 m (19...39 in/1.6...3.3 ft.)
Weight	40...70 g (0.088...0.154 lbs.)

1.3 Electrical specification

There is no isolation in the DIS module. The interfaced device, DIS module and monitor must be situated in the same patient environment (as defined in IEC 60601-1-1).

WARNING **Connecting electrical equipment together, or using the same extension cord for more than one device, may cause their leakage currents to exceed the limit specified in relevant safety standards. Always make sure that the entire combination complies with the international safety standard IEC 60601-1-1 for medical electrical systems and with the requirements of local authorities.**

1.4 Maximum power consumption

450 mW (30 mA @ 15 V) 900mW peak.

1.5 Module communication

Bus communication speed is 500 kbps. RS422 implementation.

Device communication speed depends on the interfaced external device. RS232 implementation.

2 Functional description

The S/5™ Device Interfacing Solution provides a seamless link between external patient care devices and the Datex-Ohmeda S/5 Monitoring system. You can interface simultaneously up to ten external devices: monitors, ventilators, blood gas analyzers, etc.

The Device Interfacing Solution is designed for use with the S/5 Anesthesia Monitor and Compact Anesthesia Monitor, and S/5 Critical Care Monitor and Compact Critical Care Monitor. The Device Interfacing Solution (DIS) is only compatible with the S/5 Anesthesia and S/5 Critical Care Monitor, when the monitor has B-UPI4(NET) and B-CPU4 boards installed. Also, DIS is only compatible with the S/5 version (i.e. F-CM(REC)1 frame) of the Compact Anesthesia and Compact Critical Care monitor. In addition, the S/5 Monitors must be equipped with DIS compatible main software. The Device Interfacing Solution, N-DISxxx, cannot be used with AS/3 and CS/3 Compact Monitors.

WARNING **The manufacturer guarantees a reliable functioning of the devices with tested software versions only. Always refer to the Installation guide accompanying the DIS module and verify the compatibility before use.**

2.1 Main components

The implementation of Device Interfacing Solution can be divided into five parts:

- Device specific software
- Device specific module
- Device specific cable
- Bus cables
- Software in Datex-Ohmeda Monitor

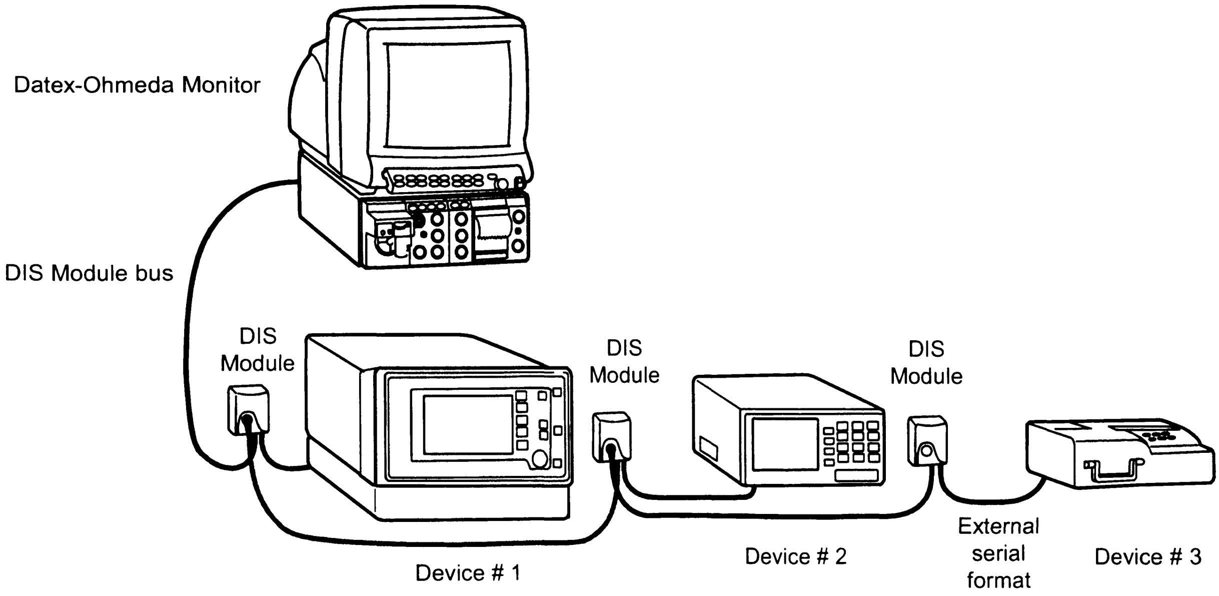


Figure 2 Implementation of Device Interfacing Solution

2.2 DIS module

A DIS module receives data from an external device, converts the data to a suitable format for the monitor and then sends the data to the monitor. The main board contains the power supply with a current limiter, microcontroller, reset circuits, memory and serial communication buffers. The board communicates with the Datex-Ohmeda Monitor through the DIS bus.

A DIS module consists of:

- Power supply with current limiter and reset circuit parts
- Microcontroller H8, internal and external RAM, non volatile memory, etc.
- Programming connection
- Device communication connection and RS232 driver
- Bus communication connection and RS422 driver
- LEDs that indicate the status of the communication
- Device specific software

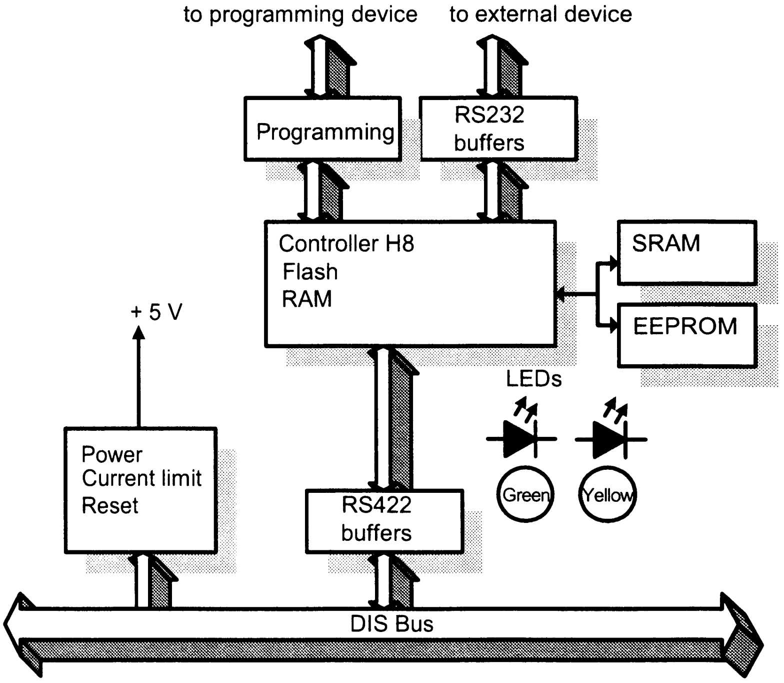
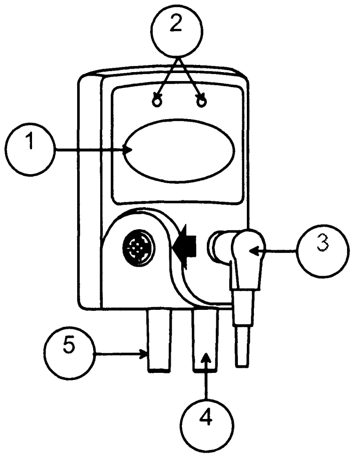

to programming device
to external device
Programming
RS232 buffers
Controller H8
Flash
RAM
SRAM
EEPROM
+ 5 V
LEDs
Green
Yellow
Power
Current limit
Reset
RS422 buffers
DIS Bus

Figure 3 DIS module working principle diagram

2.3 Connections

Connect the device specific cable to the external device and the bus cable to the Datex-Ohmeda Monitor's DIS connector, B-UPI4(NET) board, or to another DIS module.

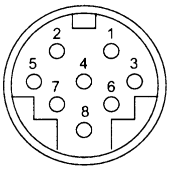


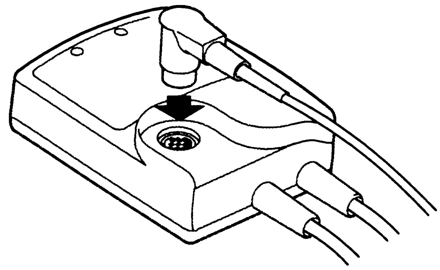
(1)	label specifying the external device
(2)	LED indicators
(3)	black bus cable from another interfacing module, if needed
(4)	grey device specific cable to the communication port of the external device
(5)	black bus cable to the monitor's DIS connector (or to another interfacing module)

Figure 4 Connection cables and LED indicators

2.4 Connectors and signals

2.4.1 Male bus cable connector





Pin No.	**Signal**	**Color**
1	Data from UPI +	brown
2	Data from UPI -	red
3	VDD 9 V to 18 V (max 1 A)	orange
4	GND	yellow
5	VCC 7 V to 8 V (max 1 A)	blue
6	GND	grey
7	Data to UPI +	white
8	Data to UPI -	black

2.5 Interfaced devices

See the following table of DIS modules and devices that you can interface with the Device Interfacing Solution.

For specific information on parameters transferred from the interfaced device to the Datex-Ohmeda monitor and the applicable software versions of the device, refer to the Installation guide accompanying each DIS module.

Table 1 DIS modules and interfaced devices

	Device Ventilators	
N-DISEV4	Evita 4[a]	
N-DISPRIM	Primus[1.]	NOTE: Not available in the US
N-DIS7200	7200 Series Ventilator System[b]	
N-DIS840	840 Ventilator System[2.]	
N-DISS300	Servo Ventilator 300[c]	
N-DIS7900	7900 SmartVent Ventilator[d]	
N-DISAEST[e]	Aestiva/5[4.]	
N-DISVENT	S/5 Aespire[4.] Aestiva/5[4.] Aisys Carestation[4.] S/5 Avance[4.] Centiva/5[4.] Engström Carestation[4.]	

a. Trademark of Dräger Medical AG & Co
b. Trademark of Nellcor Puritan Bennet Inc
c. Trademark of Maquet Critical Care AB part of the Getinge Group (previously trademark of Siemens)
d. Trademark of GE Healthcare Finland Oy
e. Replaced by N-DISVENT

	Device Monitors	
N-DISOXIM3	Oximetrix 3[a]	
N-DISQVUE	QVue /Q2[1.]	
N-DISA2000	A-2000 Bispectral Index Monitoring System[b]	
N-DISVIGIL	Baxter-Vigilance[c]	
N-DISPICCO	PiCCO-Technology[d]	NOTE: Not available in the US
N-DISRGM	RGM Monitor[e]	
N-DISTONO	Tonocap[5.]	

N-DISWHITE	Capnomac, Capnomac II[5.] Multicap, Normocap, CD2-02[5.] Capnomac Ultima[5.] Normocap CD-200[5.] Oscar Oxy, Cardiocap 1GS, Cardiocap 2GS[5.] Satlite, Satlite Trans, Satlite Plus[5.]

a. Trademark of Hospira Inc. (previously trademark of Abbott Laboratories)
b. Trademark of Aspect Medical Systems
c. Trademark of Edwards Lifesciences Corporation
d. Trademark of Pulsion Medical Systems
e. Trademark of GE Healthcare Finland Oy

	Device Blood gas analyzers
N-DISOPT	AVL Opti CCA[a]
	Device Heart-lung machines
N-DISHL20	Jostra HL-20[b]

a. Trademark of Diamond Diagnostics Inc
b. Trademark of MAQUET GmbH & Co. KG part of the Getinge Group

3 Service procedures

3.1 General service information

The field service of the Device Interfacing Solution is limited to replacing faulty cables or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
Screwdrivers		

3.2.2 Recommended parts

No recommended parts.

3.2.3 Visual inspection

Disconnect the DIS module from the DIS bus and from the interfaced external device.

1. Internal check
   - Disassemble the DIS module.
   - Make sure that there are no loose parts inside the DIS module.
   - Check that the screws holding the PC board are tightened properly.
   - Check that the cables are attached properly and the connectors are intact.

✍

2. External check
    - Check that the DIS module case and label are clean and intact.
    - Reassemble the DIS module.
    - Check that the screws for the DIS module case are secured properly.
    - Check that the bus cable connector is intact.
    - Check that the DIS bus and device specific cables are intact.

3.2.4 Functional inspection

3. DIS module interface status

    Connect the DIS module to the DIS bus and to the external device that is specified in the DIS module label, if possible. Turn on the interfaced external device.

    Check that no error messages are displayed on the monitor screen.

    Check via the Interfacing menu that the connected DIS module status is correct:

    Monitor Setup - ***Interfacing*** - ***Status Page***

    Check that the waveforms and numeric fields are transferred to the monitor according to the configuration.

4. Recognition of interface

    Disconnect the DIS bus cable and check that the '[device name] module removed' message appears on the monitor screen. Reconnect the cable.

    Turn off the external device (if possible) and check that the '[device name] disconnected from module' message appears onto the screen. Turn the external device back on again.

5. DIS module service menu

    Enter the service menu:

    Monitor Setup - ***Install/Service*** (password 16-4-34) -
    Service (password 26-23-8) -
    Parameters - More - DIS Interfacing

    Check that the menu displays submenus for all connected DIS modules.

    Enter the corresponding DIS module service menu and check that the displayed information corresponds with the information on the DIS module labels.

    Check that the DIS bus voltage is between 6.00 ...8.00 V or 10.00... 12.00 V (depending on the N-DISxxx version and the host monitor).

    Check that the DIS module time-out and checksum error values do not increase more than by 5 per second.

    Check that the status of each DIS module memory indicates OK.

6. Electrical safety check

   Perform the electrical safety test and leakage current test.

   ✍

7. Functioning after electrical safety check

   Check that the DIS module functions normally after the tests.

   ✍

8. Final cleaning

   Clean the DIS module, the bus cable and the device specific cable with a suitable detergent.

   ✍

- Fill up all the necessary documents.

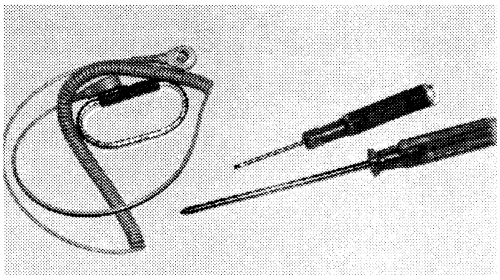
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.4 To disassemble the module

To disassemble the N-DISxxx module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws from the back of the module.
2. Loosen the two strain-relief threads and after that disconnect the cables from the connectors.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 LED indicators

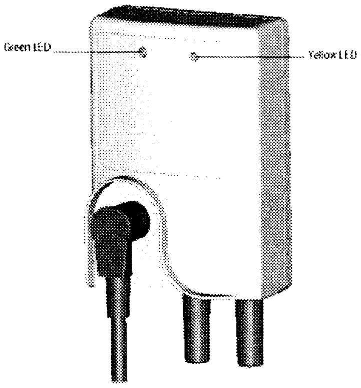


Figure 5 LED indicators

4.1.1 Green LED

The meaning of the green LED is to indicate that communication between the monitor and DIS module and communication between the DIS module and external device is working properly. When all cables are connected and the connected devices are on, the green LED should be lit continuously.

4.1.2 Yellow LED

The meaning of the yellow LED is to alert the user. The yellow LED is lit when any of the following conditions becomes true:

1. The DIS module is connected to the DIS bus, but the external device is not connected.
2. The external device is in power off state.
3. The external device is not selected from the interfacing menu as an active source of data.

NOTE: The meaning of the yellow LED varies with some external devices. See the "Installation Guide" delivered with the DIS module.

4.2 Quick functional check

You have two ways for checking the function of the Device Interfacing Solution:

- Press the **Monitor Setup** key, select ***Interfacing*** and open the ***Status Page*** menu. The status page shows you the current communication status of the interfacing modules connected to the bus (1... pcs).

NOTE: The status message 'Connected' appears on the monitor screen after you have connected the external device to the DIS module and turned it on, if the monitor and DIS module have already been initialized.

- Check the LED indicators on the DIS module (the green LED indicates the physical connections, the yellow LED software selections):

GREEN	YELLOW	INDICATION
lit ●	dark ○	Physical connections between the monitor, DIS module and external device are in order and the device has been selected in the menu.
dark ○	lit ●	There is something wrong with the physical connections between the monitor, interfacing module and external device. The external device has not been selected in the menu.
lit ●	lit ●	Physical connections between the monitor, DIS module and external device are in order, but the external device has not been selected in the menu (see the "User's Reference Manual" of the monitor).
dark ○	dark ○	The DIS module is not connected to the monitor.

5 Earlier revisions

This manual supports all earlier N-DISxxx revisions.

APPENDIX A Service check form, Device Interfacing Solution, N-DISxxx (Rev. 00 and Rev. 01)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal check	☐	☐	☐	2. External check	☐	☐	☐
Notes							
Functional inspection							
3. DIS module interface status	☐	☐	☐	4. Recognition of interface	☐	☐	☐
5. DIS module service menu	☐	☐	☐	6. Electrical safety check	☐	☐	☐
7. Functioning after electrical safety check	☐	☐	☐	8. Final cleaning	☐	☐	☐

Notes

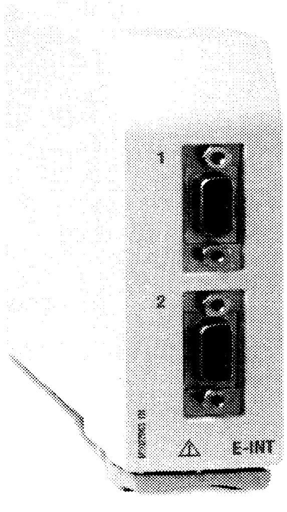
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Interface Module, E-INT (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027836
June, 2005

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Appendix A: Service check form, Interface Module, E-INT (Rev. 00) A-1

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Interface Module, E-INT. The Interface module is a single width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Interface Module, E-INT, provides an interface between the S/5 Monitors and other external monitors such as Datex-Ohmeda Cardiocap and Capnomac Ultima, Criticon Dinamap 1846 SX, and Abbott Oximetrix 3.

NOTE: The Interface Board, B-INT, and Interface Module, E-INT, cannot be used simultaneously in the same monitor.

1 Specifications

1.1 General specifications

Module size (W × D × H)	37 x 190 x 112 mm / 1.5 x 7.5 x 4.4 in
Module weight	0.35 kg / 0.8 lb.

1.2 Serial I/O definitions

- RS-232 buffered (channels 1-2)
- All standard baud rates are possible from 300 to 115200
- Each interfaced device has a fixed baud rate.

1.3 Analog definitions

- There are four analog inputs available on channel 1 and four on channel 2.
- All analog inputs are Op-Amp buffered, with an input impedance of 1 M. Each analog input is also equipped with a 1 MΩ pull-down resistor to -12 V for NC detection.
- Sampling rate: 10 ms/sample/channel
- Input range: -10 V...+10 V
- Resolution: 10 bits → 1024 voltage levels in input range

2 Functional description

The Interface Module, E-INT, detects and identifies the external monitors connected to the module. The identification is made by a serial string, sent by the external monitor.

When an external monitor is connected to the Interface Module, numeric data is always displayed on the monitor screen. Also, analog real time waveforms are displayed, if the external monitor is able to send them.

Connections from the Interface Module to external monitors are isolated from the S/5 Monitor.

2.1 Main components

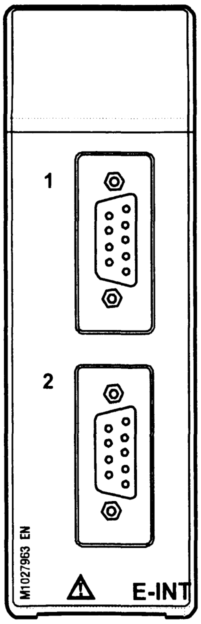


Figure 1 Front panel of Interface Module, E-INT

1. Serial/analog connector (X2) CH1
2. Serial/analog connector (X3) CH2

2.1.1 External connections

The connectors on the Interface Module are:

- One 25-pin D-connector X1 for the module bus.
- Two 9-pin connectors, X2 and X3, for external monitors. These are internally connected to two 9-pin female D-connectors via ribbon cables.

Each X2 and X3 connector has an RS-232 serial communication channel and four analog inputs.

2.1.2 RS-485 Serial communication

The Interface Module uses RS485 signal levels when communicating with the external monitor. The RS485 signals are transformed to digital signal levels and fed via an opto-isolator to the microprocessor. The communication signals for transmitting (TxD) and receiving (RxD) data are sent to the microprocessor ports. The direction of the communication is controlled by REC/SND signals, generated by the microprocessor, via the opto-isolator. When the module bus is reset, the communication is always set to the receiving state.

2.1.3 Reset

The interface board resets when the module bus is reset. The RESET signal is converted from an RS-485 signal level to a digital signal level and then fed to an opto-isolator. The RESET signal is renamed to POWEROK signal. The POWEROK signal resets the microprocessor and the GAL circuit.

2.1.4 RS-232 Serial communication

A QUART is used to provide four serial communication channels with external monitors. However, only two channels are used. The microprocessor controls resetting of the QUART during normal operation. When the microprocessor is reset the QUART is also reset.

2.1.5 Memories

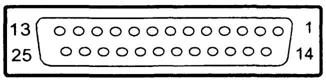
There are static RAM, ROM, EEPROM memories in the Interface Module. The memory decoding is done with the GAL circuit. The microprocessor communicates with the EEPROM memory in serial mode.

Analog inputs

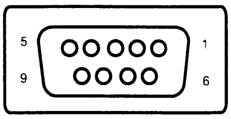
Eight analog inputs from the serial/analog connectors are connected to eight low pass filters. The frequency limit (-3 dB) is set to 35 Hz. The input signal levels are between -10 V and +10 V, and the output signals are scaled between 0 V and 5 V. The output signals are then fed to the microprocessor A/D inputs.

2.2 Connectors and signals

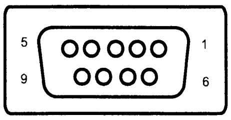
2.2.1 Module bus connector

Module bus connector (X1)	Pin No.	I/0	Signal
	1	0	RESET_RS485
	2	0	-15 VDC
	3	0	+15 VDIRTY
	4	0	+15 VDC
	5	I/0	-DATA_RS485
	6	I/0	DATA_RS485
	7		Ground & Shield
	8	0	-RESET_RS485
	9	0	CTSB
	10	I	RTSB
	11	0	RXDB
	12	I	TXDB
	13		Ground & Shield
	14	0	+32 VDIRTY
	15	0	GroundDIRTY
	16	0	CTSC
	17	I	RTSC
	18	0	RXDC
	19	I	TXDC
	20		ON/STANDBY
	21		BITOIN
	22		RXDD_RS232
	23		TXDD_RS232
	24	0	+5 VDC
	25	0	+5 VDC

2.2.2 Serial/analog connector CH1

Serial/analog connector (X2) CH 1 (floating, off-board)	Pin No.	Definition
	1	A0 analog input
	2	RXD
	3	TXD
	4	A1 analog input
	5	GND
	6	A2 analog input
	7	RTS
	8	CTS
	9	A3 analog input

2.2.3 Serial/analog connector CH 2

Serial/analog connector (X3) CH 2 (floating)	Pin No.	Definition
	1	A4 analog input
	2	RXD
	3	TXD
	4	A5 analog input
	5	GND
	6	A6 analog input
	7	RTS
	8	CTS
	9	A7 analog input

3 Service procedures

3.1 General service information

The field service of the Interface Module, E-INT, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Datex-Ohmeda gas monitor with the SpO_2 measurement		e.g. ULT-S
INT Interface cable	892377	
Calibration gas		
SpO_2 probe		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal check

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all socket mounted IC's are inserted properly

- the EMC cover is attached properly
- there are no loose objects inside the module

2. External check

   Check that:

   - the front cover and the front panel sticker are intact
   - the block screws for cables are in place and tightened properly
   - the block screw threads are intact
   - all connectors are intact and attached properly
   - the module box and latch are intact

   Reattach the module box and check that the latch moves properly.

3.2.3 Functional inspection

3. Installation

   Plug the Interface Module into the monitor Central Unit. Check that it goes in smoothly and locks up properly.

4. Interface selection

   Connect the Datex-Ohmeda gas monitor with the interface cable (order code 892377) to Interface Module, E-INT, connector 1. Lock the cable properly.

   Turn both monitors on.

   Make sure the serial output mode of the Datex-Ohmeda gas monitor being used is set to NUMERIC.

   Configure the S/5 Monitor screen so that all required parameters are shown, for example:

   Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 5 - Pleth***
   Field 6 - Co2

   Set the interface for the Datex-Ohmeda gas monitor being used:

   Monitor Setup - ***Install/Service (password 16-4-34) - Installation -***
   Interfacing - Gases/Spiro - XXX
   SpO2 - XXX

   XXX = the gas monitor being used

   Check that the menus ***NIBP*** and ***SvO2/C.O***. are selectable from the menu.

5. Module software

   Enter the service menu:

Monitor Setup - ***Install/Service (password 16-4-34) - Service (password 26-23-8)***

Take down the information regarding the Interface Module, E-INT, software by selecting ***Scroll vers*** and turning the ComWheel.

6. Communication and memories

   Enter the Interface service menu:

   Parameters - More - Interface

   Check that the Time-outs, Bad checksums and Bad c-s by mod values are not increasing faster than by 5 per second. Check that the Interface Module E-INT memories have passed the internal memory test, i.e. RAM and ROM state OK.

7. Recognition of connection

   Check that the interfaced gas monitor is identified, i.e. the required waveform fields are shown on the screen and the gas monitor type is shown correctly on the service menu.

   Check that the communication state is online.

8. Gas interface (1)

   Select ***Gases*** from the Interface service menu.

   Check that id: states the correct monitor and interface type, Active states YES and Time-out NO.

   Check that the numeric values on the service menu are reasonable.

   Simulate breathing by feeding calibration gas into the Datex-Ohmeda gas monitor sampling line and check that the values on the service menu correspond with the values on the gas monitor screen.

   Check that the values in the S/5 Monitor gas waveform field are correct and a proper CO_2 waveform is shown.

   Stop feeding the calibration gas. Check that the message 'Apnea' appears in the S/5 Monitor waveform field, and in the message field, if the selected interface type is ULT/al.

9. SpO_2 interface (1)

   Select ***SpO2*** from the Interface service menu.

   Check that id: states the correct monitor and interface type, Active states YES and Time-out NO.

   Check that ProbeOff shows 1 when no SpO_2 probe is connected to the interfaced gas monitor. Connect the SpO_2 probe and check that the NoProbe shows 1.

   Attach the SpO_2 probe to your finger and check that the values on the menu correspond with the values on the gas monitor screen.

   Check that the values in the S/5 Monitor pleth waveform field are correct and a proper pleth waveform is shown.

Disconnect the SpO_2 probe. Check that the message 'Probe off' appears in the S/5 Monitor waveform field, and 'SpO_2 probe off' appears in the message field, if the interface type is ULT/al.

✍

10. Recognition of disconnection

    Turn the gas monitor off. Check that the messages 'Interfaced Gas monitor removed' and 'Interfaced SpO_2 monitor removed' appear on the S/5 Monitor screen.

    ✍

11. Interface (2)

    Turn the S/5 Monitor off. Connect the gas monitor with interface cable to Interface Module, E-INT connector 2.

    Turn the monitors on and check that the necessary numerics and waveforms are still interfaced, together with the alarms, if the interface type is ULT/al.

    ✍

12. Restarting

    Disconnect the Interface Module, E-INT, for a moment, then plug the module back into the monitor.

    Check that interfacing with the gas monitor is restored.

    ✍

13. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

14. Functioning after electrical safety check

    Check that the Interface Module, E-INT, functions normally after performing the electrical safety check.

    ✍

    Set the interface back for modules:

    Monitor Setup - ***Install/Service (password 16-4-34)*** - ***Installation*** -
    Interfacing - ***Gases/Spiro*** - ***Module***
    Sp02 - ***Module***

15. Final cleaning

    Clean the module with suitable detergent.

- Fill in all necessary documents.

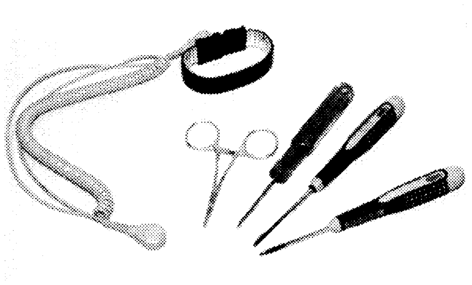
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver, T10
- flat blade screwdriver
- pincers
- antistatic wristband

To disassemble the module

To disassemble the Interface Module, E-INT (see the exploded view of the module box and E-INT in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. To detach the circuit board, remove the four screws and disconnect the two ribbon cables from the front panel.

To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

Enter the Service Menu (see the “Service Menu” slot of the Monitor “Technical Reference Manual”). Select ***Scroll vers*** and scroll down the SW version/Unit id list. Make sure that the software code and level, control and serial numbers of the Interface Module, E-INT, are displayed under INT.

If they are not displayed, the Interface Module, E-INT, is faulty.

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
Interface menu item not active in the Service Menu. Software version and ID data are not available in the Service Data field.	Module is not connected properly. E-INT is faulty	Check that the module is firmly pushed into the module slot. Replace E-INT Interface board.
Measured values from the interfaced monitor do not appear on the display after approximately one minute.	Monitor not selected for interface. Poor contact in the interface cables. Wrong interface cable.	Select the right monitor from the Interfacing menu. Check the cables and connections. Change the cable to another connector. Check cable type and change if necessary.

Earlier revisions

There are no earlier revisions of the S/5™ Interface Module, E-INT.

APPENDIX A Service check form, Interface Module, E-INT (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
1. Internal check	☐	☐	☐	2. External check	☐	☐	☐
Functional inspection							
3. Installation	☐	☐	☐				
4. Interface selection	☐	☐	☐				
5. Module software	E-INT						
6. Communication and memories	☐	☐	☐	7. Recognition of connection	☐	☐	☐
8. Gas interface (1)	☐	☐	☐	9. SpO2 interface (1)	☐	☐	☐
10. Recognition of disconnection	☐	☐	☐	11. Interface (2)	☐	☐	☐
12. Restarting	☐	☐	☐				
13. Electrical safety check	☐	☐	☐	14. Functioning after electrical safety check	☐	☐	☐
15. Final cleaning	☐	☐	☐				

Notes			

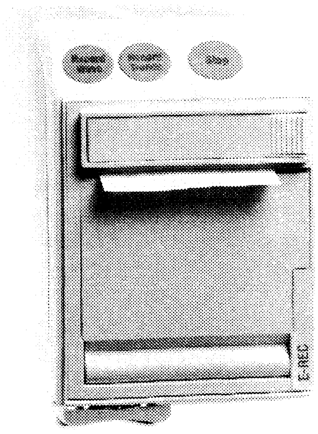
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Recorder Module, E-REC (Rev. 00)

Technical Reference Manual Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027837
June, 2005

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Appendix A: Service check form, Recorder Module, E-REC (Rev. 00) A-1

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Recorder Module, E-REC. The REC module is a double width plug-in module designed for use with the Datex-Ohmeda modular monitors. Later in this manual the module may be referred to without S/5 for simplicity.

The service menu is described in a separate “Service Menu“ slot and the spare part lists in the “E-Modules Spare Parts” slot.

The Recorder Module, E-REC, provides real time printing of waveform and numerical data, and trend data.

The S/5 Compact Monitors may include a built-in recorder. The built-in recorder is technically the same as the Recorder Module.

NOTE: Printings on thermal paper may be destroyed when exposed to light, heat, alcohol, etc. Take a photocopy for archive.

NOTE: The Recorder Module, E-REC, cannot be used in the Extension Frame, F-EXT4.

NOTE: The Recorder Module, E-REC, functions with all monitor software versions.

NOTE: The Recorder Module, E-REC, is not compatible with the Compact Monitor frames that contain the built-in recorder (F-CMREC, F-CMCREC, F-CMREC1 and F-CMCREC1).

1 Specifications

Module size, W x D x H	75 x 192 x 112 mm / 3.0 x 7.6 x 4.4 in
Module weight	0.85 kg/ 1.9 lb.
Power consumption	3 W
Principle	Thermal array
Print resolution	
Vertical	8 dots/mm (200 dots/inch)
Horizontal	32 dots/mm (800 dots/inch) at a speed of 25 mm/s and slower
Paper width	50 mm, printing width 48 mm
Traces	Selectable 1, 2, or 3 traces
Print speed	1, 6.25, 12.5, 25 mm/s

2 Functional description

2.1 Main components

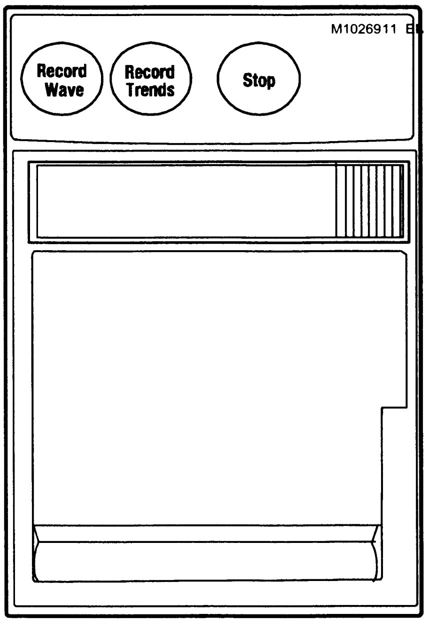


Figure 1 **Front panel of Recorder Module, E-REC**

Record Wave key	records selected real-time waveforms. Recording time depends on the recording length.
Record Trends key	prints numerical, graphical or tabular trends. Recording time depends on the recording length and trend resolution.
Stop key	stops recording or trend printing.

2.1.1 Recorder board

The function of the recorder board is to establish an interface between the recorder unit and main CPU board in the monitor. The three front panel keys are connected to the recorder unit via the recorder board. The recorder unit and the recorder board are connected together with a small connector board and a 12-pin flex-strip cable.

External communication

Communication with the main CPU board is established via a +5 V CMOS level RS232 serial interface, with an RS485 reset.

Reset The differential RS485 reset from the module bus generates a Recorder Unit reset signal on the Recorder Board. The Recorder Board also generates a power-up-reset, whose time constant is approximately 0.1 second. The Recorder Unit reset signal is therefore active when either the Module Bus RS485-reset or the power-up-reset is active.

+5 V priority The recorder unit supply voltage, +15 VREC, is switched on after +5 V is present.

Front panel keys The recorder board can read the three front panel keys and pass their status on to the main CPU board.

To protect the keypad signals from static discharges, zener diodes and series resistors are used. Separate pull-up resistors are not needed, because pull-up resistors connecting the keypad input signals to +5 V are inside the recorder.

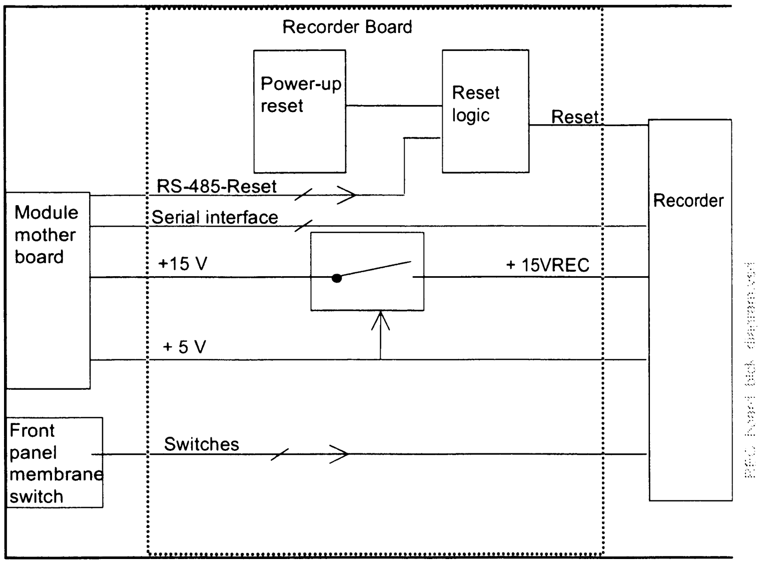
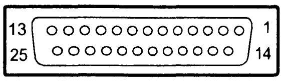

Recorder Board
Power-up reset
Reset logic
Reset
RS-485-Reset
Module mother board
Serial interface
Recorder
+15 V
+ 15VREC
+ 5 V
Front panel membrane switch
Switches

Figure 2 **Recorder board block diagram**

2.2 Module bus connector

Module bus connector (X1)	**Pin No.**	**I/O**	**Signal**
	1	I	RESET_RS485
	3	I	+15 VDIRTY
	7	-	Ground & Shield
	8	I	-RESET_RS485
	9	0	CTSB
	10	I	RTSB
	11	0	RXDB
	12	I	TXDB
	13	-	Ground & Shield
	15	I	GroundDIRTY
	24	I	+5 VDC
	25	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the Recorder Module, E-REC, is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Multiparameter hemodynamic module		
Patient simulator		
Torx screwdriver, T10		

3.2.2 Recommended parts

Part	**Order No.**	**Notes**
Recorder paper	74205	

3.2.3 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly

- there are no loose objects inside the module

✍

2. External parts

   Check that:

- the front cover and the front panel sticker are intact
- the module box and latch are intact

✍

Reattach the module box and check that the latch moves properly.

3.2.4 Functional inspection

3. Paper compartment cleaning

   Open the paper compartment hatch and take out the paper roll, if installed.

   Remove any paper chaff from the paper compartment.

   Clean the thermal printhead and the small glass window in front of the static brush with a cotton swab dipped in isopropyl alcohol. Avoid contact with the rubber paper roller.

NOTE: Be careful to limit the application of alcohol to the thermal printhead and the window.

Leave the paper compartment empty and close the hatch.

✍

Turn the monitor on and wait until the normal monitoring screen appears.

Configure the monitor screen so that all required parameters are shown, for example:

Monitor Setup - ***Screen 1 Setup - Waveform Fields - Field 1 - ECG1***
Field 2 - ECG2
Field 3 - P1
Field 4 - P2
Field 5 - PLETH
Field 6 - OFF

Insert the Hemodynamic Module into a module slot. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.

Preset recording settings:

Record/Print - ***Record Waveforms - Waveform 1 - ECG1***
Waveform 2 - P1
Waveform 3 - P2
Delay - Off
Paper Speed - 6.25 Mm/S
Length --> 30 S

Record Trends - Graphic Trend 1 - Hr
Graphic Trend 2 - P1

Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Installation*** - ***Printer & Recorder*** - ***Default Trend*** - ***Graph.***

Display Trends - ***Time Scale*** - ***2 h***

4. Installation

   Plug in the Recorder Module. Check that the module goes in smoothly and locks up properly.

   ✍

5. Paper recognition

   Press the **RECORD WAVE** key on the module front panel. Check that the message 'Recorder: Out of paper' appears on the screen.

   ✍

6. Cover state recognition

   Open the paper compartment cover. Check that the previous message changes to 'Recorder: Cover open'.

   Install a paper roll and close the cover. Check that the message 'Recorder: Cover open' disappears from the screen.

   ✍

7. Front panel membrane keys

   Press the **RECORD WAVE** key again and check that the module starts recording the selected waveforms. Press the **STOP** key on the module front panel to stop recording.

NOTE: If no recording appears, check that the paper roll is installed correctly - only one side of the paper is printable.

   Press the **PRINT TRENDS** key and check that the module starts recording graphical trends. Wait until the recording stops.

   ✍

8. Quality of recording

   Check that the quality of the recordings is acceptable.

   ✍

9. Recording speed

   Press the **RECORD WAVE** key again and this time wait until the recording stops. Check that the length of the recorded waveform scale is 18.7 cm (±1.5 cm).

   Change the paper speed setting to 1 mm/s:

   Record/Print - ***Record Waveforms*** - ***Paper Speed*** - ***1 mm/s***

Press the **RECORD WAVE** key and wait until the recording stops. Check that the length of the scale is now 3.0 cm (±0.5 cm).

✍

10. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

11. Functioning after electrical safety check

    Check that the module functions normally after performing the electrical safety check.

    ✍

12. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

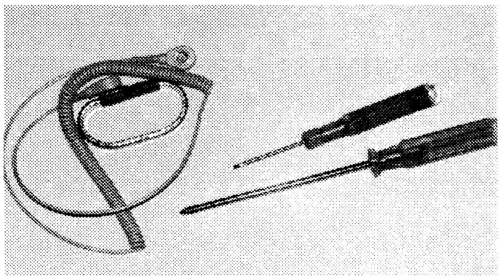
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver; T10
- flat blade screwdriver
- antistatic wristband

3.3.3 To disassemble the module

To dissassemble the Recorder Module, E-REC (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. Remove the two screws (T10) from the back of the module.
2. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
3. Open the recorder unit paper loading hatch. Loosen the two screws at the bottom of the recorder unit housing with a long blade screwdriver.
4. Disconnect the 50-pin connector from the back of the recorder unit and the 5-pin ribbon keypad connector from the recorder board.

The recorder unit and front panel frame can now be pulled out of the main body. The front panel frame is pulled out of the recorder by pulling backward.

The recorder board is attached to the metal chassis with four screws.

CAUTION The recorder board is fixed to the metal chassis at the factory in a specific position. The recorder board and chassis must therefore not be separated.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting chart

Problem	**Cause**	**What to do**
Module not responding to front panel keys, but operates through **Recorder** key in ***Record*** menu.	Membrane switch cable loose or broken.	Check the cable. Replace the front panel if necessary.
	E-REC: Flex-strip cable broken	Check the cable. Replace if necessary.
	E-REC: Bad contact on connector board.	Check contact.
Recorder will not start. No error messages shown.	E-REC: Module not properly inserted.	Re-insert the module properly.
	E-REC: Flex-strip cable broken.	Check the cable. Replace if necessary.
	E-REC: Connector board loose.	Check connector board connections.
	Recorder board faulty.	Replace the recorder board.
	Recorder unit faulty.	Replace the recorder unit.
Recorder works but nothing appears on the paper.	Active side of the paper downwards.	Turn the paper roll over. To test which side is active: Place the paper on a hard surface and draw a line with a fingernail - a dark line will appear on the active (thermal) side.
	Recorder unit faulty.	Replace the recorder unit.

4.2 Messages

Problem	**What to do**
Recorder: out of paper	Release paper jam or insert a roll of paper into the recorder.
Recorder: cover open	Close the recorder cover correctly.
Recorder: thermal array overheat	Recorder overheated. Stop using and allow it to cool down.
Recorder: input voltage low	+15 Vrec is too low. Check flex-strip cable and connector board.

Problem	**What to do**
Recorder: input voltage high	+15 Vrec is too high. Check flex-strip cable and connector board.
Recorder system error 1, 2, 3	System error. Remove the recorder module and re-insert it. If the problem persists, replace the recorder unit.
Recorder: module removed	The module not in place, or a communication error due to a fault in the module or in the main CPU board.

5 Earlier revisions

There are no earlier revisions of the S/5™ Recorder Module, E-REC.

APPENDIX A Service check form, Recorder Module, E-REC (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	**OK**	**N.A.**	**Fail**		**OK**	**N.A.**	**Fail**
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Paper compartment cleaning	☐	☐	☐	4. Installation	☐	☐	☐
5. Paper recognition	☐	☐	☐	6. Cover state recognition	☐	☐	☐
7. Front panel membrane keys	☐	☐	☐	8. Quality of recording	☐	☐	☐
9. Recording speed				Measured value	Allowed range		
6.25 mm/s					17.2...20.2 cm		
1.0 mm/s					2.5...3.5 cm		
10. Electrical safety check	☐	☐	☐	11. Functioning after electrical safety check	☐	☐	☐
12. Final cleaning	☐	☐	☐				
Notes							

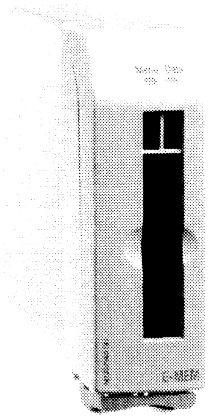
Used spare parts			

Signature

Datex-Ohmeda

S/5™ Memory Module, E-MEM (Rev. 00)

Technical Reference Slot



All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027817
June, 2005

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Appendix A: Service check form, Memory Module, E-MEM (Rev. 00) A-1

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 MEM Module, E-MEM. The Memory Module, E-MEM, is an optional data storage single width module designed for Datex-Ohmeda modular monitors. Later in this manual modules may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The Memory Module is used for storing patient related physiological data, discrete record keeping events, menu configurations and user defined monitor configurations in removable PCMCIA[1] compatible memory cards.

The memory module can be utilized in the following applications:

- As a backup media for patient related physiological and record keeping data.
- As a local menu server for the monitor it is attached to.
- A memory card with its previously recorded patient data can be transported to a new monitor location with the patient, enabling continuous data collection.
- To save and load user defined monitor configurations.

The memory module is available in one version:

- Single width external plug-in Memory Module, E-MEM, for S/5 Critical Care and Anesthesia monitors.

The memory module has two card slots, which use rewritable PCMCIA-ATA specification compatible memory cards: Data and Menu Cards.

The data card is used for storing patient related data and record keeping events, and the menu card is used as a storage media for pre-recorded menu configurations and user defined monitor configurations. If the module is used only for data backup and transportation, the Menu card is not necessarily required. Similarly, if only record keeping configurations are needed, the data card does not have to be present. In the latter case, however, no physiological or event data can be stored in a memory card.

Module software runs under MS-DOS[2] compatible operating system provided by Datalight[3]. The files created in Data and Menu MemCards are MS-DOS compatible.

[1] PCMCIA = Personal Computer Memory Card International Association

[2] MS-DOS is a trademark of Microsoft Corporation

[3] Datalight is a trademark of Datalight, Inc.

The communication between the monitor CPU and the memory module is performed with a high-speed internal TTL level RS-232 serial interface. Data transfer rate is 76.8 kbps.

Compatibility

NOTE: Memory Module, E-MEM, cannot be used in the **Extension Frame, F-EXT4** and in the **S/5 Compact Monitors**.

1 Specifications

1.1 General specifications

1.1.1 E-MEM

Module size (W × D × H)	37 x 187 x 112 mm/1.5 x 7.4 x 4.4 in
Module weight	0.35 kg/0.8 lb.
Total power consumption	2 W maximum

1.2 Technical specifications

MemCard capacity	32 MB
Data storage capacity	2 days of continuous physiological data trends
Operating system	Datalight ROM-DOS
File system	MS-DOS compatible
MemCards	PCMCIA-ATA compatible memory cards

2 Functional description

The Memory Module, E-MEM, contains a memory board and a LED (Light Emitting Diode) board attached to the front panel.

The front panel has a dual PCMCIA card connector for two MemCards. There are two push buttons above the card slots for removing the MemCards from the module, and two memory card specific LEDs. The LEDs are on during memory card read and write operations to notify the user not to remove them until the operation is complete.

2.1 Main components

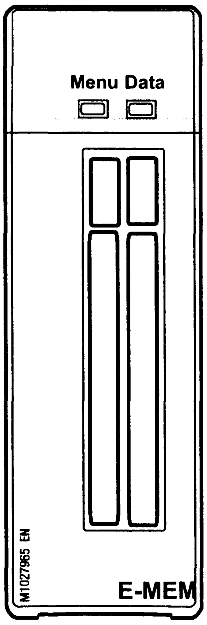


Figure 1 **Front panel of Memory Module, E-MEM**

2.1.1 Memory board

Processor section

Basically, the memory module is a single board PC with any unnecessary I/O functions removed. The processor is Intel 80C186 compatible and the software runs under the DOS operating system. Operating frequency is 16 MHz. The board has 512 kB RAM, 448 KB ROM, 128 kB EEPROM and associated buffer circuits for memory operations.

The Intel 82365SL compatible PC Card Interface Controller (PCIC) provides all the functions needed in MemCard operations. Serial communication, EEPROM read and write operations and LED control is accomplished through a QUART circuit. In addition, the processor board contains a circuitry to control reset signals and MemCard programming voltages.

The memory module board block diagram is shown in Figure 2.

PCMCIA card interface

E-MEM has PCMCIA compatible card sockets for two MemCards. Both sockets consist of 60 signal and 8 power connections. MemCards are PCMCIA-ATA compatible, and their memory capacity is 6 MB.

All MemCard read and write operations as well as card power management are controlled by a PCIC interface controller.

Card removals and insertions are also detected by the interface controller.

MemCard files are MS-DOS compatible and they can be copied for archiving with any MS-DOS compatible computer equipped with any PCMCIA-ATA specification compatible card drive.

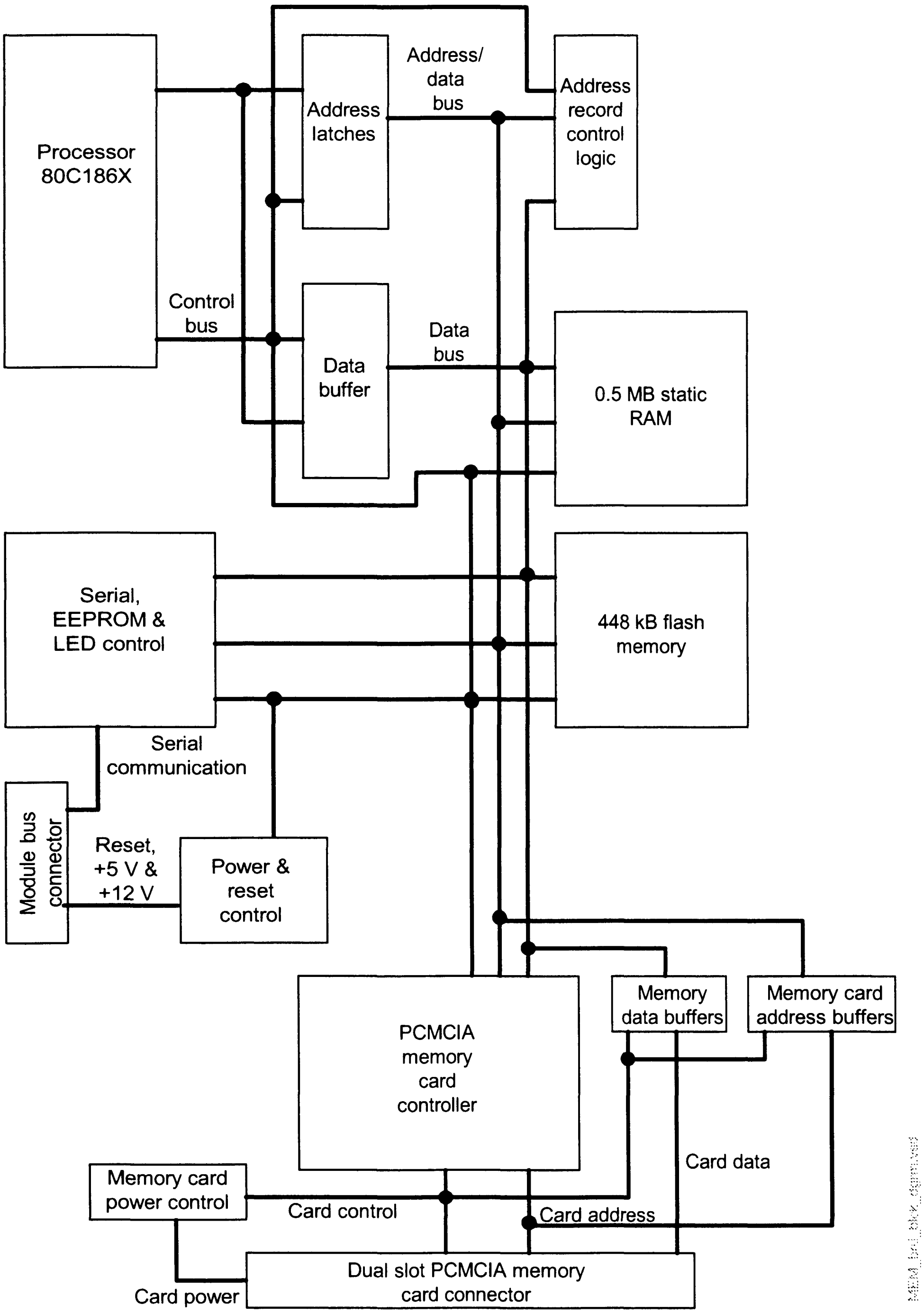

Processor
80C186X
Address latches
Address/
data
bus
Address
record
control
logic
Control
bus
Data
buffer
Data
bus
0.5 MB static
RAM
Serial,
EEPROM &
LED control
448 kB flash
memory
Serial
communication
Module bus
connector
Reset,
+5 V &
+12 V
Power &
reset
control
PCMCIA
memory
card
controller
Memory
data buffers
Memory card
address buffers
Card data
Memory card
power control
Card control
Card address
Dual slot PCMCIA memory
card connector
Card power
MEM_brd_blck_dgm.vsd

Figure 2 **Memory board block diagram**

Serial communication

Serial communication between the module and main CPU board is performed through a module bus TTL-level RS-232 interface. The data transfer rate is 76.8 kbps.

An RS485 type monitor reset signal is converted to module reset by an interface transceiver, and power reset is generated by a reset circuit.

Power supply

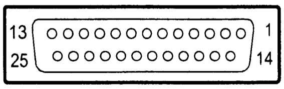
The module receives its power (+5 V, +15 V) from the monitor. The PCMCIA card programming voltage +12 V is generated from +15 V by voltage regulators. Card programming voltage is controlled by an interface controller. Otherwise, only +5 V power is used in the module. Maximum power consumption is 2 W.

LED board

The LED board contains only two yellow light emitting diodes and a three-lead cable to the memory board.

2.2 Connectors and signals

2.2.1 Module bus connector

Module bus connector	Pin No.	I/O	Signal
	1	I	RESET_RS485
	4	I	+15 VDC
	7	-	Ground & Shield
	8	I	-RESET_RS485
	13	-	Ground & Shield
	16	O	CTSC
	17	I	RTSC
	18	O	RXDC
	19	I	TXDC
	24	I	+5 VDC
	25	I	+5 VDC

2.2.2 LED board connector (X5)

Pin No.	I/0	Signal
1	0	+5 V
2	0	LED1 control
3	0	LED2 control

2.2.3 Connector board connector (X1)

Pin No.	I/0	Signal
1	I	Ground & Shield
2	I	Ground & Shield
3	I	-RESET_RS485
4	I	+15 VDC
5	I	RESET_RS485
6	0	CTSC
7	I	RTSC
8	0	RXDC
9	I	TXDC
13	I	+5 VDC
14	I	+5 VDC

3 Service procedures

3.1 General service information

The field service of the memory module is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
MemCard - Menu (PCMCIA-ATA)		
MemCard - Data (PCMCIA-ATA)		
Hemodynamic module		
Patient simulator		
Torx screwdriver, T10		

3.2.2 Visual inspection

Detach the module box by removing the two screws from the back of the module.

1. Internal parts

   Check that:

   - screws are tightened properly
   - cables are connected properly
   - all IC's that are on sockets are attached properly
   - EMC covers are attached properly

- there are no loose objects inside the module

✍

2. External parts

   Check that:

   - the front cover and the front panel sticker are intact
   - the memory card housing frame is intact
   - the module box and latch are intact

   ✍

   Reattach the module box and check that the latch is moving properly.

3.2.3 Functional inspection

Switch the monitor on and wait until the monitoring screen appears.

Configure the monitor screen so that all the needed parameters are shown, for example as follows:

Monitor Setup - ***Screen 1 Setup*** - ***Waveform Fields*** - ***Field 1*** - ***ECG1***
Field 2 - ***ECG2***
Field 3 - ***P1***
Field 4 - ***P2***
Field 5 - ***PLETH***
Field 6 - ***OFF***

Insert the hemodynamic module. Connect a patient simulator to the module and check that all connected parameters are shown on the screen.

3. Installation

   Plug in the Memory Module without memory cards. Check that the module goes in smoothly and locks up properly.

   ✍

4. Front panel LEDs

   Check that both LEDs on the module's front panel light up briefly, when the module is connected.

   ✍

5. Module software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding the MEM software by selecting ***Scroll Vers*** and turning the ComWheel.

   ✍

6. Module recognition

   Enter the memory module service menu:

   ...***Frame - MemCards***

   Check that the module is recognized properly, i.e. Module present and Module active state YES.

   ✍

7. Memories and PCMCIA controller

   Check that the Memory board memories and the PCMCIA controller have passed their tests. The status for each should be OK.

   ✍

8. Communication

   Enter the memory cards ***Communication*** menu:

   Select ***...Frame - Communication***.

   Check that the Interface status states continuously ACTIVE and the error counter values on the bottom part of the menu are stable.

   ✍

9. Menu-card recognition

   Enter the memory module service menu:

   Select ***...Frame - MemCards***

   Insert a Memory card labelled Menu in the left hand side memory card slot. Check that the message 'Menu Card inserted' appears on the message field and the white menu card symbol on the upper right hand corner of the screen within 1 minute.

NOTE: The battery symbol overrides the memory card symbols in the Compact Monitor.

   Wait until the information regarding SLOT1 is fully updated in the service menu, then check that the Card type states MENU and the File system ATA.

   Check that the rest of the information for SLOT1 is reliable and no errors have been detected.

   ✍

10. Data-card recognition

    Insert a Memory card labelled Data in the right hand side memory card slot. Check that the message 'Data Card inserted' appears on the message field and the green menu card symbol on the upper right hand corner of the screen within 1 minute.

    Wait until the information regarding SLOT2 is fully updated in the service menu, then check that the Card type states DATA and the File system ATA.

    Check that the rest of the information for SLOT2 is reliable and no errors have been detected.

    ✍

    Enter the ***Save Modes*** menu:

    Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Save Modes*** (password 13-20-31)

Save the current modes into the Menu card by selecting LOAD MODES and then TO MEMORY CARD --> SAVE. Wait until the text 'Saved' appears, then return to the previous menu.

Change the name for the mode number 1:

Highlight the mode number 1, press the ComWheel and select NAME. Select suitable characters from the list by turning and pressing the ComWheel, then confirm the new name by selecting END.

11. Menu-card functions

    Load the original modes from the Menu card by selecting LOAD MODES and then FROM MEMORY CARD --> LOAD. Wait until the text 'Loading' changes to 'Loaded', then return to the previous menu.

    Check that the mode number 1 has got back its original name.

    ✍

    Press the membrane key **Display Trends**. Check that there are enough trend information available for the monitored parameters.

    Erase the trends:

    Reset Case - ***Reset All*** - ***Yes***

    Check that the trends have been erased by pressing the key **Display Trends** again.

12. Data-card functions

    Reload the trends from the Data card by pressing the key **Patient Data**, selecting ***Patient From Card***, pressing the ComWheel on the last saved file (the file information is shown at the bottom of the menu) and selecting ***Load***.

    Wait until the message 'Loading from Mem. Module' disappears, then check that the original trends are available again by pressing the key **Display Trends**.

    ✍

13. Electrical safety check

    Perform an electrical safety check and a leakage current test.

    ✍

14. Functioning after electrical safety check

    Check that the module functions normally after the performed electrical safety check.

    ✍

15. Final cleaning

    Clean the module with suitable detergent.

    ✍

- Fill in all necessary documents.

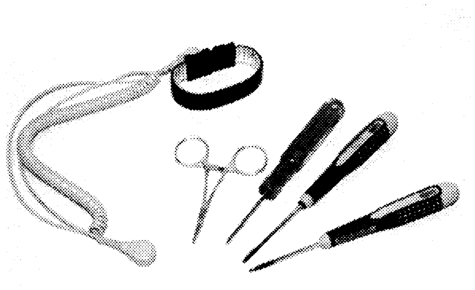
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- torx screwdriver; T10
- flat blade screwdriver
- pincers
- antistatic wristband

3.3.3 To disassemble the module

To disassemble the memory module (see the exploded view of the module in the "E-Modules Spare parts" slot):

1. To remove the Module Front Cover from the module, release the snaps that hold the front cover to the front chassis.
2. Remove the two screws (T10) from the back of the module.
3. While pressing the release latch, pull the module box slowly backwards and remove it from the main body.
4. Remove the two screws that are located on the module bus connector and the screws that connect the front panel frame to the Memory board.
5. Disconnect the LED board cable and remove the front panel frame.
6. Remove the EMC cover carefully from around the Memory board.

To reassemble the module, reverse the order of the disassembly steps.

CAUTION When reassembling the module, make sure that the cables, especially the LED board cable, are reconnected properly.

Always perform the "Service check" after reassembling the module.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Memory module

Problem	**Cause**	**What to do**
'Memory module removed' message	Module removed from monitor frame. Possible error in data communication between the module and the monitor.	Insert module in the module frame. Remove module briefly from the monitor. Insert module back to monitor frame. If the message persists, replace the memory board or the main CPU board.
'Memory module error' message	Module has detected an error condition.	If message persists, remove module for repair.
'Memory module comm. error' message	Module not properly attached to monitor frame.	Check module attachment.

4.1.2 Memory cards

Problem	**Cause**	**What to do**
'Two Data Cards in mem. module' message	Two Data cards detected.	Remove MemCard from the left hand side slot of the module.
'Two Menu Cards in mem. module' message	Two Menu cards detected.	Remove MemCard from the right hand side slot of the module.
'No menus in Menu Card' message	There are no menus in the Menu card.	Insert a Menu card with valid menu configuration files in the module.
'Faulty Data Card - change card' message	An error has occurred during Data card read/write operation	Change Data card.
'Faulty Menu Card - change card' message	An error has occurred during Menu card read/write operation	Change Menu card.

5 Earlier revisions

There are no earlier revisions of the S/5™ Memory Module, E-MEM.

APPENDIX A Service check form, Memory Module, E-MEM (Rev. 00)

Customer		
Service	Module type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
Notes							
Functional inspection							
3. Installation	☐	☐	☐				
4. Front panel LEDs	☐	☐	☐				
5. Module software	MEM						
6. Module recognition	☐	☐	☐	7. Memories and PCMCIA controller	☐	☐	☐
8. Communication	☐	☐	☐	9. Menu-card recognition	☐	☐	☐
10. Data-card recognition	☐	☐	☐	11. Menu-card functions	☐	☐	☐
12. Data-card functions	☐	☐	☐				
13. Electrical safety check	☐	☐	☐	14. Functioning after electrical safety check	☐	☐	☐
15. Final cleaning	☐	☐	☐				

Notes	

Used spare parts			

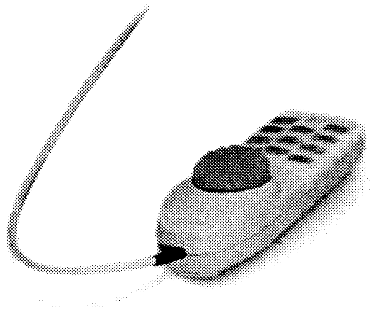
Signature	

Datex-Ohmeda

Remote Controller

S/5™ Remote Controller, K-REMCO (Rev. 01)
S/5™ Remote Controller, K-CREMCO (Rev. 00)

Technical Reference Manual Slot



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CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1027838-4
June, 2005

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Appendix A: Service check form,
Remote Controllers K-REMCO (Rev. 01) and K-CREMCO (Rev. 00) A-1

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Datex-Ohmeda S/5 Remote Controllers, K-REMCO and K-CREMCO. The Remote Controllers are designed for use with the Datex-Ohmeda modular monitors. Later in this manual the remote controllers may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

The Remote Controller, K-REMCO/K-CREMCO, brings the Command Bar/ monitor keyboard functions near to the user and allows access to the same menus as the Command Bar/ monitor keyboard.

- Remote Controller, K-REMCO for Anesthesia Monitor and Critical Care Monitor
- Remote Controller, K-CREMCO for Compact Monitors and S/5 FM.

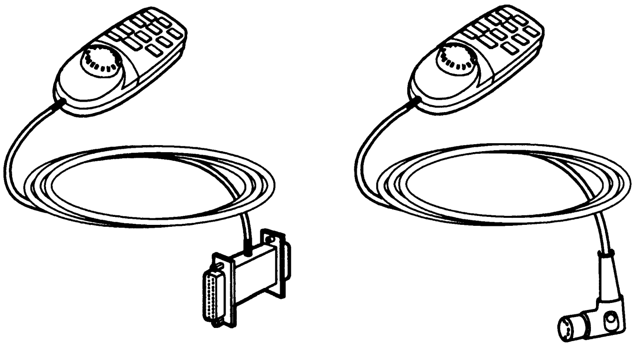


Figure 1 **K-REMCO and K-CREMCO**

Monitor software compatibility

K-REMCO and K-CREMCO require monitor software version 97 or later.

1 Specifications

1.1 Remote Controller, K-REMCO, K-CREMCO

Dimensions (without cable)	150 × 60 × 50 mm
Weight (incl. cable)	0.5 kg
Cable length	6 m
Input voltage	5 V
Power consumption	180 mW
Communication protocol	RS-232

NOTE: Power supply from the monitor only.

2 Functional description

2.1 Remote Controller, K-REMCO/ K-CREMCO

The Remote Controller consists of 12 direct function keys and the ComWheel.

2.1.1 K-REMCO/ K-CREMCO PCBs

The K-REMCO/ K-CREMCO has two PCBs located inside the Remote Controller. One board has only the push button switches of the keys. The other board reads the status of the keys and the ComWheel and forwards the information to the CPU board.

2.1.2 External communication

K-REMCO Rev.00-01

Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps. The 26-pin subminiature D-connector of the Remote Controller is connected to the Display Controller Board, B-DISP.

K-REMCO Rev.00 with optional Remote Controller - Compact Monitor cable or K-CREMCO Rev.00

Two signals, TXD and RXD in RS232 format are in use. No handshaking is used. Serial communication speed is 19.2 kbps. In Compact Monitors, the DIN 5 connector is connected to the keyboard connector X9. In S/5 FM, the DIN 5 connector is connected to Multi IO adapter X7.

2.1.3 ComWheel

The ComWheel is used for menu selection.

3 Service procedures

3.1 General service information

The field service of the remote controllers is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

These instructions include complete procedures for a service check. The service should be performed after any service repair. Additionally, the service check procedures can also be used for determining possible failures.

The procedures should be performed in ascending order.

The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	**Order No.**	**Notes**
Screwdriver		

3.2.2 Visual inspection

Turn the monitor to STBY.

Disconnect the remote controller cable from the monitor.

Detach the remote controller upper cover and the keypad cover by removing the screws (7 pcs) from the bottom.

1. Internal parts

   Check that:

   - cables are connected properly
   - the remote controller cable is fastened to the bottom cover with screws
   - the keypad switches are intact
   - the software EPROM under the keypad is attached properly

   ✍

2. External parts

   Check that:

   - the upper and bottom covers are intact
   - the keypad cover is intact
   - the ComWheel cover is intact and attached properly

   ✍

   Reassemble the remote controller.

3. Cable

   Check the remote controller cable:

   - the cable is intact
   - the cable connector is intact
   - the connector pins are clean, straight and at about the same height
   - the locking screws inside the connector case are intact

   ✍

3.2.3 Functional inspection

Reconnect the cable to the monitor and turn the monitor ON.

4. Monitor picture

   Wait until the normal monitoring screen appears, then check that the picture on the screen is displayed with correct resolution.

   ✍

5. Command board software

   Enter the service menu:

   Menu (on the remote controller keypad) - **Monitor Setup** - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding the remote controller software.

   ✍

   Select the menu ***KEYBOARD***:

   Service - Keyboard

6. Remote controller keys

   Press the keys one by one. Check that each key generates a sound from the loudspeaker.

   ✍

7. ComWheel

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound and the corresponding values at the bottom of the menu increase.

   Select DUMMY PRESS. Push the ComWheel and check that the push generates a sound and the corresponding value in the menu increases.

   ✍

8. Electrical safety check

   Perform an electrical safety check and a leakage current test.

   ✍

9. Functioning after electrical safety check

   Check that the remote controller functions normally after the performed electrical safety check.

   ✍

10. Final cleaning

    Clean the remote controller and the cable.

    ✍

- Fill in all necessary documents.

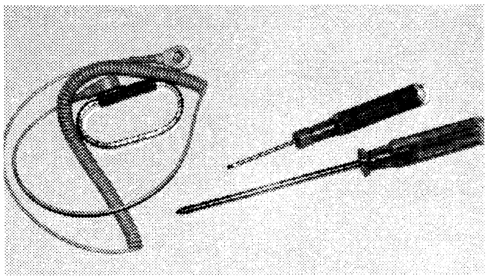
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.3.3 To disassemble Remote Controller K-REMCO / K-CREMCO

To disassemble the Remote Controller (see Figure 2):

1. Disconnect the K-REMCO/ K-CREMCO cable from the monitor.
2. Pull out the knob of the ComWheel.
3. Open the nut on the shaft of the ComWheel.
4. Open the three cross head screws on the bottom of the K-REMCO/ K-CREMCO.
5. Remove the top cover.
6. Open the four screws on the bottom of the K-REMCO/ K-CREMCO.
7. Remove the keyboard cover.
8. Disconnect the K-REMCO/ K-CREMCO cable and the wire set from the Comwheel.
9. Remove the PCBs.

For more information on the spare parts, see the “E-Modules Spare parts” slot.

In reassembly, remember to put the reinforcing cord of the cable around the screw on the metal bridge before tightening the screw.

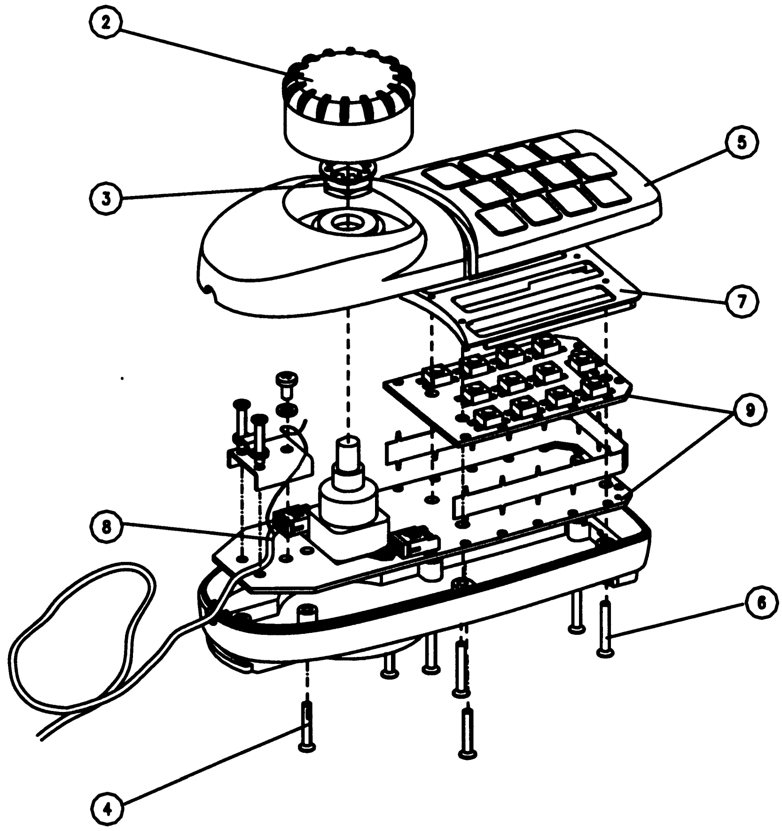


Figure 2 K-REMCO, K-CREMCO disassembly and reassembly

To reassemble the module, reverse the order of the disassembly steps.

In reassembly, remember to put the reinforcing cord of the cable around the screw on the metal bridge before tightening the screw.

CAUTION When reassembling the remote controller make sure that the cables are reconnected properly.

Always perform the "Service check" after reassembling the remote controller.

4 Troubleshooting

4.1 K-REMCO, K-CREMCO

See Keyboard Service Menu in the “Service Menu“ slot and perform tests available. If any of the tests fail, see explanation below.

Problem	**Cause**	**What to do**
ComWheel not working	ComWheel leads broken or connector loose. ComWheel faulty.	Check the items. Replace the ComWheel if necessary.
Membrane key not working	Switch cable loose or broken. Keyboard cable loose or broken. Cable connector pin failure. RS232 communication failure on CPU board.	Check the items. Replace them if necessary.

APPENDIX A Service check form, Remote Controllers K-REMCO (Rev. 01) and K-CREMCO (Rev. 00)

Customer		
Service	Keyboard type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	N.A.	Fail		OK	N.A.	Fail
1. Internal parts	☐	☐	☐	2. External parts	☐	☐	☐
3. Cable	☐	☐	☐				
Notes							
Functional inspection							
4. Monitor picture	☐	☐	☐				
5. Command board software	KB						
6. Remote controller keys	☐	☐	☐	7. ComWheel	☐	☐	☐
Notes							
8. Electrical safety check	☐	☐	☐	9. Functioning after electrical safety check	☐	☐	☐
10. Final cleaning	☐	☐	☐				

Notes

Used spare parts			

Signature

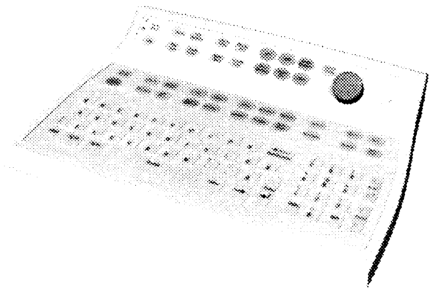
Datex-Ohmeda

Anesthesia Record Keeping Keyboard, K-ARKB (Rev. 00)

S/5™ Keyboard Interface Board, B-ARK (Rev. 00)

ARK Barcode Reader, N-SCAN (Rev. 00)

Technical Reference Manual Slot



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M1027839
June, 2005

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Appendix A: Service check form,
Anesthesia Record Keeping Keyboard, K-ARKB (Rev. 00) **A-1**

Introduction

This Technical Reference Manual slot provides information for the maintenance and service of the Anesthesia Record Keeping Keyboard, K-ARKB, the S/5 Keyboard Interface Board, B-ARK, and the ARK Barcode Reader, N-SCAN. The information is applicable for the current production revisions of the devices. Later in this manual the board may be referred to without S/5 for simplicity.

The service menu is described in a separate "Service Menu" slot and the spare part lists in the "E-Modules Spare Parts" slot.

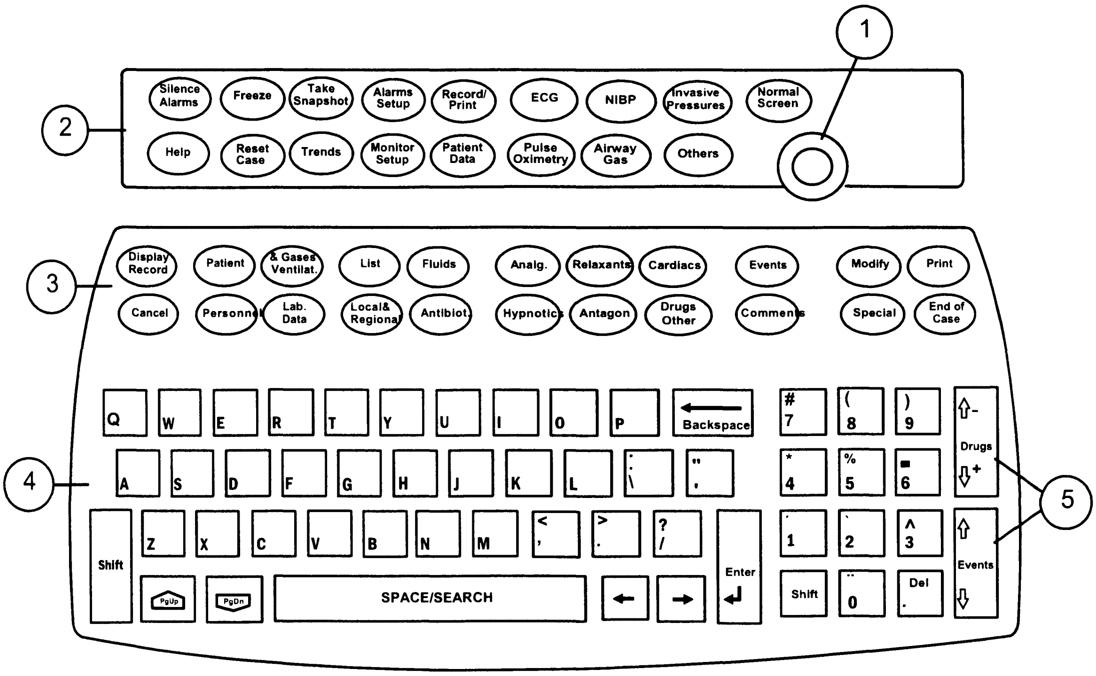

1
2
3
4
5
Silence Alarms
Freeze
Take Snapshot
Alarms Setup
Record/ Print
ECG
NIBP
Invasive Pressures
Normal Screen
Help
Reset Case
Trends
Monitor Setup
Patient Data
Pulse Oximetry
Airway Gas
Others
Display Record
Patient
& Gases Ventilat.
List
Fluids
Analg.
Relaxants
Cardiacs
Events
Modify
Print
Cancel
Personnel
Lab. Data
Local& Regional
Antibiot
Hypnotic
Antagon
Drugs Other
Comments
Special
End of Case
Q W E R T Y U I O P
Backspace
# 7
(8
) 9
Drugs
A S D F G H J K L
; \
" '
* 4
% 5
6
Shift
Z X C V B N M
< ,
> .
? /
Enter
1
2
^ 3
Events
PgUp
PgDn
SPACE/SEARCH
Shift
0
Del

Figure 1 Anesthesia Record Keeping Keyboard, K-ARKB (English version)

(1) The ComWheel

(2) Keys that function as the S/5 Monitor's command bar. The power switch is in the monitor's Command Bar.

(3) Keys for record keeping control.

(4) Letter and number keys for typing in information that is not listed in the menus.

(5) Arrow keys (Drugs, Events) for moving up or down the Event list and Event trend when the record is on the display.

NOTE: The S/5 Keyboard Interface Board, B-ARK, can only be used with the S/5 Anesthesia Monitor and the AS/3 Anesthesia Monitor.

Monitor software compatibility

The K-ARK and K-ARKB keyboards are compatible with monitor software versions:
S-ARK94 and later, L-ARK99(A), L-00A03/04, L-00A07/08 and L-ANE01(A) and later.

Related documents

For more information about...	See
Technical issues	"Technical Reference Manual" of the S/5 Monitor, Part I
Configuration	Anesthesia Record Keeping Solution, user documentation
Contents of the menus in your hospital	Contact the personnel responsible for the menu configurations in the hospital
Monitor, parameters, physiological trends, general messages and symbols on the display	"Datex-Ohmeda S/5 Anesthesia Monitor, User's Guide" and "User's Reference Manual"
Printer	The printer manual
Barcode Reader	The Barcode Reader manual

1 Specifications

1.1 General specifications

1.1.1 Keyboard, K-ARKB

Dimensions (W × D × H)	328 × 232 × 61 mm/12.9 × 9.1 × 2.4 in
Weight	1.3 kg/3.8 lbs.
Power	+5 V DC ±10%, 70 mA max, supplied from S/5 AM or S/5 CM
Character set	ASCII
Communication interface	PC compatible serial line plus S/5 type serial line
Environmental requirements:	
Operating temperature	+10...+35 °C/+50...+95 °F
Storage temperature	-10...+45 °C/+14...+113 °F
Humidity	10...90% non-condensing

1.1.2 ARK Barcode Reader, N-SCAN

Dimensions (W × L × H)	7.1 12.7 × 16 cm/2.8 × 5 ×6.3 in
Weight approx.	170 g/5.98 oz. (w/o cable)
Power	supplied from S/5 Monitor or AS/3 AM or AS/3 CM
Light source	675 nm laser diode
Laser classifications	CDRH Class II, IEC Class 1, IEC 825 Class 2
Environmental requirements:	
Operating temperature	0...+40 °C/+32...+104 °F
Storage temperature	-40...+60 °C/-40...+140 °F
Humidity	5...95% non-condensing
Durability	withstands 1.2 m drop to concrete

2 Functional description

2.1 Introduction

The Anesthesia Record Keeping Solution is an automated anesthesia documentation system. For the Anesthesia Record Keeping Solution, the record keeping configurations from the network and a memory module, and optionally the keyboard, K-ARKB, are needed.

The Anesthesia Record Keeping Solution is connected to the network, and runs in S/5 AM or S/5 CAM. The Memory Module, E-MEM (N-CMMEM), is needed for backup data storage.

The Anesthesia Record Keeping Solution combines the physiological data measured by the monitor, information automatically integrated from external devices such as S/5 ADU, and the information manually entered into a printable anesthesia record using the menus. The record can be stored in electronic format for later review/printing and for statistical analysis.

2.2 Anesthesia Record Keeping Keyboard, K-ARKB

The Anesthesia Record Keeping Keyboard, K-ARKB, consists of a controller board, alphanumeric keyboard and membrane keyboard.

2.2.1 Controller board

The controller board reads the status of the keyboard keys and the ComWheel, and forwards the information to the CPU board in the monitor through an RS232 serial interface.

Additionally, the board controls the LEDs on the K-ARKB front panel.

External communication

Communication with the CPU board takes place in the RS232 serial communication channel which is available on the CPU bus. There are also two bidirectional signals (Data and Clock) for PCKB format communication.

For serial communication, the Anesthesia Record Keeping Keyboard, K-ARKB, is connected to the S/5 Anesthesia Monitor central unit by a 9-pin-26-pin interface cable. The cable is connected to Keyboard Interface Board, B-ARK, or to Display Controller Board, B-DISP in the F-CU8 or F-CPU.

In case of PCKB type communication, the Keyboard can be connected to the S/5 LCD Display, D-LCC10A, D-LCC12A or to the S/5 Compact Monitor.

CPU

The CPU on the controller board is of type 80C51FA and the oscillator frequency is 11.059 Mhz. There is a power-up-reset whose time constant is about 1 second.

Serial communication

The RS232 serial communication IC needs only +5 V supply voltage, because it chops the necessary RS-level supply voltages to its external capacitors. A diode allows the use of two keyboards, and a pull-down resistor on the CPU board is used for pulling the corresponding line to the negative RS-level. The speed rate of the serial communication is 19.2 kbps.

LEDs

The CPU on the controller board controls the alarm LEDs according to commands received from the main CPU board.

2.2.2 Alpha-numeric keyboard

The controller board reads the status of the keys on the alphanumeric keyboard. The boards are connected together with a 26-pin ribbon cable.

2.2.3 Membrane keyboard

The controller board reads the status of the keys on the membrane keyboards. The membrane keyboard and the controller board are connected together with a ribbon cable.

2.3 Keyboard Interface Board, B-ARK

The Keyboard Interface Board, B-ARK, is installed in the central unit of the S/5 Anesthesia Monitor. It has a 26-pin D-connector to which the Anesthesia Record Keeping Keyboard, K-ARKB, is connected. The board passes the keyboard signals to the central unit.

2.4 ARK Barcode Reader, N-SCAN

The ARK Barcode Reader, N-SCAN, is an optional device to make record keeping faster by using bar codes. With the Barcode Reader, the user has direct access to a menu item by reading a bar code mapped to the menu item. Barcodes can also be used for pushing and turning the ComWheel and opening the main menus (L-ARK99(A) or later).

WARNING **When using the ARK Barcode Reader, N-SCAN, do not stare into beam. The ARK Barcode Reader, N-SCAN, is a Class 2 laser product.**

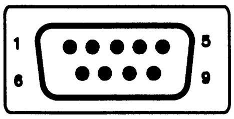
2.5 Connectors and signals

2.5.1 Connectors on the Anesthesia Record Keeping Keyboard, K-ARKB

Barcode Reader 5-pin connector

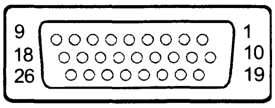
Pin No.	Signal
1	PC-CLOCK
2	PC-DATA
3	N.C.
4	GND
5	+5 V

Anesthesia Record Keeping Keyboard 9-pin connector

	Pin No.	I/O	Signal
	1	I/O	PC-DATA
	2	I	RX
	3	O	TX
	4	I	+5 V
	5		GND
	6	I	RESET
	7	-	GND
	8	-	N.C.
	9	I/O	PC-CLOCK

2.5.2 Connectors on the Keyboard Interface Board, B-ARK

26-pin connector (X3)

	Pin No.	I/O	Signal
	1		N/C
	2		N/C
	3		N/C
	4		N/C
	5		N/C
	6	O	Ground
	7		N/C
	8		N/C
	9		N/C
	10		N/C
	11		N/C
	12		N/C
	13		N/C
	14		N/C
	15	O	+ 5 V
	16		N/C
	17		N/C
	18		N/C
	19	I	RxD RS232
	20	O	TxD RS232
	21		N/C
	22		N/C
	23		N/C
	24		N/C
	25		N/C
	26		N/C

CPU bus connector (X1)

Pin No.	a	b	c
1	+15 V	AGND	DGND
2	-15 V	BALE	DGND
3	SA0	SA1	DGND
4	SA2	SA3	RESET_RS485
5	SA4	SA5	-RESET_RS485
6	SA6	SA7	DATA_RS485
7	SA8	SA9	-DATA_RS485
8	SA10	SA11	TXDD_RS232
9	SA12	SA13	RXDD_RS232
10	SA14	SA15	BIT0IN
11	SA16	SA17	BIT1IN
12	SA18	SA19	TXDC
13	SA20	SA21	RXDC
14	SA22	SA23	RTSC
15	-SMEMR	-SMEMW	CTSC
16	-IOR	-IOW	TXDB
17	CLK	-RESET	RXDB
18	-IOCHRDY	IRQ10	RTSB
19	N/C_1	IRQ11	CTSB
20	N/C_2	IRQ12	TXDA
21	-SBHE	IRQ15	RXDA
22	SD0	SD1	RTSA
23	SD2	SD3	CTSA
24	SD4	SD5	LOUDSPEAKER
25	SD6	SD7	+5 V
26	SD8	SD9	+5 V
27	SD10	SD11	+5 V
28	SD12	SD13	+5 V
29	SD14	SD15	ON/STBY
30	+15 VD	-RESET_CPU	+5 V_CPU
31	+15 VD	+32 VD	REFRESH_WD
32	GNDD	GNDD	POWER_FAIL

3 Service procedures

3.1 General service information

The field service of the K-ARKB Keyboard is limited to replacing faulty circuit boards or mechanical parts. The circuit boards should be returned to GE Healthcare for repair.

GE Healthcare is always available for service advice. Please provide the unit serial number, full type designation, and a detailed fault description.

CAUTION Only trained personnel with appropriate equipment should perform the tests and repairs outlined in this section. Unauthorized service may void the warranty of the unit.

3.2 Service check

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The instructions include a check form ("APPENDIX A") which should be filled in when performing the procedures.

The symbol ✍ in the instructions means that the check form should be signed after performing the procedure.

3.2.1 Recommended tools

Tool	Order No.	Notes
B-ARK		with AM
Screwdriver		

3.2.2 Visual inspection

1. Cable

   Disconnect the interface cable from the Anesthesia Record Keeping Keyboard, K-ARKB, and check the cable:

   - the connector pins are clean and straight and at about the same height
   - the locking screws are intact
   - the cable is intact

   Leave the cable disconnected.

   ✍

2. Internal check

   Detach the bottom cover and check internal parts:

- all screws are tightened properly
- the block screws for the interface cable are in place and tightened properly
- the block screw threads are intact
- the interface cable connector is clean and intact
- all internal cables are connected properly
- all IC's that are on sockets are attached properly
- there are no loose objects inside

Reattach the bottom cover, reconnect and lock the interface cable to the Anesthesia Record Keeping Keyboard, K-ARKB.

✍

3. External check

   Check that:

   - the Anesthesia Record Keeping Keyboard, K-ARKB, plastic frame is intact
   - the front panel stickers are intact
   - the ComWheel cover is intact and attached properly
   - all four rubber pads are in place on the bottom cover

   ✍

   Install the B-ARK into the Central Unit. Connect and lock the interface cable to the B-ARK rear panel connector.

3.2.3 Functional inspection

4. ON LED

   Switch the monitor on. Check that the LED on the upper right hand corner of the Anesthesia Record Keeping Keyboard, K-ARKB, is lit up.

   ✍

5. Software

   Enter the service menu:

   Monitor Setup - ***Install/Service*** (password 16-4-34) - ***Service*** (password 26-23-8)

   Take down the information regarding the Anesthesia Record Keeping Keyboard, K-ARKB, software.

   ✍

6. Alarm LEDs

   Select the menu ***Keyboard*** with the ComWheel.

   Highlight the text ***Upper Led***. Check that the red alarm LED is turning on and off on the Anesthesia Record Keeping Keyboard, K-ARKB, when pressing the ComWheel.

Check also the yellow alarm LED by selecting ***Lower Led*** from the menu.

✍

7. ComWheel

   Check the ComWheel.

   Turn the ComWheel clockwise and counterclockwise and check that each step generates a sound from the loudspeaker and the corresponding values at the bottom of the menu increase.

   Select ***Dummy Press***. Press the ComWheel and check that the press generates a sound and the corresponding value in the menu increases.

   ✍

8. Membrane keys

   Check the membrane keys of the Anesthesia Record Keeping Keyboard, K-ARKB.

   Press the keys on the upper part of the Anesthesia Record Keeping Keyboard, K-ARKB, one by one. Check that each key generates a sound from the loudspeaker and the corresponding text in the menu changes from yellow to red.

   Press the keys on the lower part, all except the keys **Modify** and **Print**. Check that each key generates a sound from the loudspeaker, or at least the Message count value increases in the service menu.

   Press the keys **Modify** and **Print** and check that the corresponding menus open on the screen.

   ✍

9. Electrical safety check

   Perform an electrical safety check and aleakage current test.

   ✍

10. Functioning after electrical safety check

    Check that the Anesthesia Record Keeping Keyboard, K-ARKB, functions normally after the performed electrical safety check.

    ✍

11. Final cleaning

    Clean the Anesthesia Record Keeping Keyboard, K-ARKB, with suitable detergent.

    ✍

- Fill in all necessary documents.

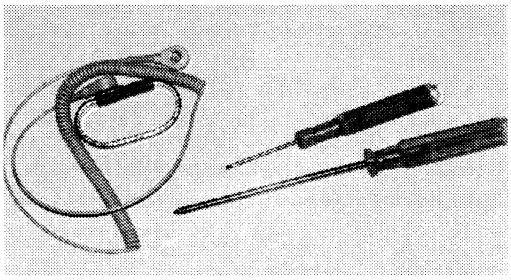
3.3 Disassembly and reassembly

3.3.1 Before disassembly

NOTE: Wear a grounded, antistatic wristband when handling PC boards. Electrostatic discharge may damage components on the board.

NOTE: Handle all PC boards by their edges.

3.3.2 Tools needed



- screwdriver
- flat blade screwdriver
- antistatic wristband

3.4 To disassemble the keyboard

To disassemble the Anesthesia Record Keeping Keyboard, K-ARKB (see the exploded view of the K-ARKB keyboard in the “E-Modules Spare parts” slot):

1. Disconnect the ARK keyboard - monitor cable (ARK keyboard - LCD display cable).
2. Remove the four screws from the bottom of the keyboard, and detach the cover plate from the bottom plate.

4 Troubleshooting

4.1 Troubleshooting charts

4.1.1 Anesthesia Record Keeping Keyboard, K-ARKB

Problem	Cause	What to do
Keys have no effect on the display.	Cable is not connected or broken. Wrong type of cable is connected. Loose connector inside. Component failure inside.	Connect right type of cable properly (see above). Detach the bottom plate and check connectors and components.
Membrane key not working.	Ribbon cable loose or broken. Keyboard cable loose or broken. D-connector pin failure. IC failure on the Controller board. RS232 communication failure on the main CPU board. NOTE: The cancel key does not respond if the menu is closed. The modify key may not work if there is no selection.	Check the items. Replace them if necessary.
Led does not light at alarm or stays lit after alarm is over.	Cable loose or broken. LED broken. Component failure on the Controller board.	Check the items. Replace them if necessary.

See more troubleshooting items in “User’s Reference Manual”.

4.1.2 Barcode Reader

Problem	Cause	What to do
Barcode Reader does not give a beep sound	Beep sound is OFF.	Contact personnel responsible for installing and configuring the monitors. ***Bar Code Beep*** should be ***ON*** in **Monitor Setup - *Install/Service - Installation - Monitor Settings*** menu. Password is required for the selection.
Nothing happens when trying to use the Barcode Reader.	Cable connections are not properly connected.	Confirm that the cables are properly connected.

Problem	Cause	What to do
Barcode Reader opens a ***Search*** menu but nothing else happens.	Menu directory does not have a Barcode Reader file.	Contact personnel responsible for installing and configuring the monitors.
Barcode Reader led flashes and you may hear a beep sound, but nothing else happens.	1. Barcodes are not included in the configuration. 2. Barcode Reader is not correctly programmed. 3. Monitor is not connected to the network and the memory module does not have a menu card inside. 4. Monitor has an old configuration which is not updated. 5. Old software version on monitor.	1. Contact personnel responsible for installing and configuring the monitors. 2. Contact personnel responsible for installing and configuring the monitors. The Barcode Reader should be reprogrammed. See the instructions following the Barcode Reader. 3. Connect the monitor to the network or insert a menu card into the memory module. 4. Contact personnel responsible for installing and configuring the monitors. 5. Please upgrade your monitor. 6. NOTE: Possible connecting cables are 881152 and Y-piece or 8001117.
Search result seems to mix different menu items.	Menu files have been modified after which they have not been recompiled with the map files.	Contact personnel responsible for installing and configuring the monitors. The menu files have to be recompiled together with the map files.

See more troubleshooting items in the Barcode Reader manual.

5 Earlier revisions

Information on Anesthesia Keyboard, K-ARK rev. 00, see Service Manual 885 941.

Information on Anesthesia Keyboard, K-ARK rev. 02, see Technical Reference Manual 896 624.

Previous Bar Code Reader (by HP) rev. 00, see Technical Reference Manual 895 585.

APPENDIX A Service check form, Anesthesia Record Keeping Keyboard, K-ARKB (Rev. 00)

Customer		
Service	Keyboard type	S/N
Service engineer		Date

OK = Test OK **N.A. = Test not applicable** **Fail = Test failed**

Visual inspection	OK	**N.A.**	**Fail**		OK	**N.A.**	**Fail**
1. Cable	☐	☐	☐	2. Internal check	☐	☐	☐
3. External check	☐	☐	☐				
Functional inspection							
4. ON LED	☐	☐	☐				
5. Software	KB						
6. Alarm LEDs	☐	☐	☐	7. ComWheel	☐	☐	☐
8. Membrane keys	☐	☐	☐				
9. Electrical safety check	☐	☐	☐	10. Functioning after electrical safety check	☐	☐	☐
11. Final cleaning	☐	☐	☐				

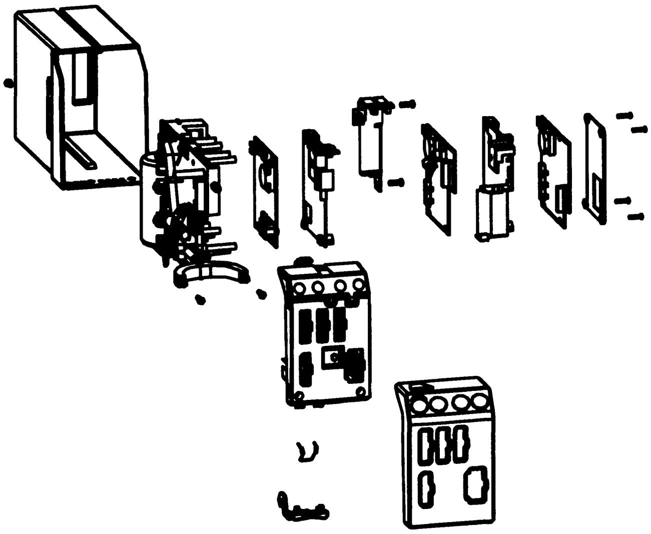
Notes

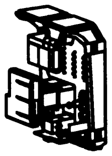
Used spare parts			

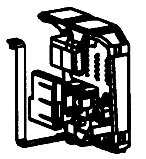
Signature

Datex-Ohmeda

S/5^{TM} E-Modules, Spare Parts







All specifications are subject to change without notice.
CAUTION: U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.
Outside the USA, check local laws for any restriction that may apply.

M1044469
June, 2005

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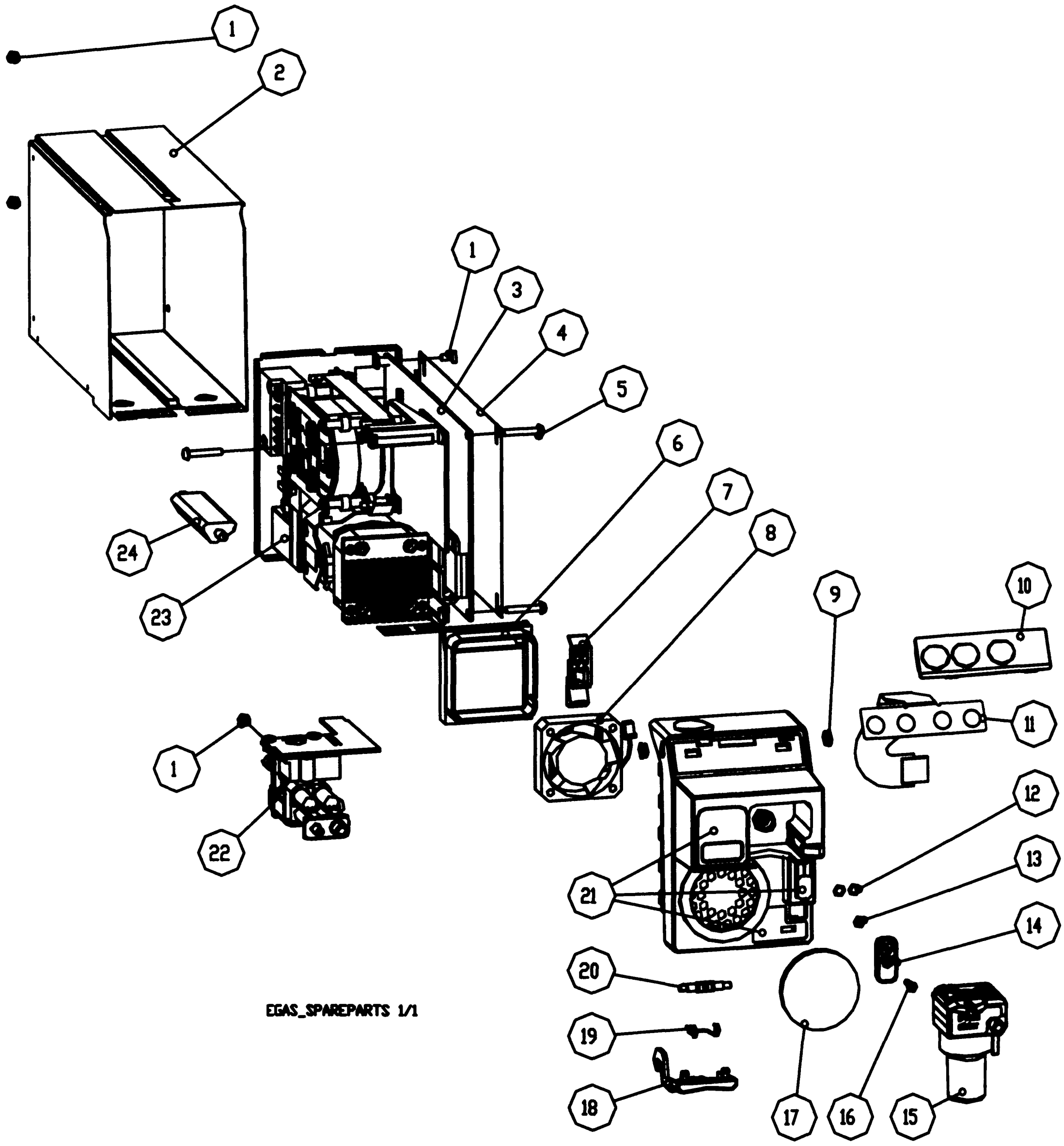
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EGAS_SPAREPARTS 1/1

Item	Description	Order No.
	Nafion tubing 300mm	733382
1	SCREW, machine screw, M3x6mm, DIN7985 ISO7045, Pozidrive, pan head, steel, zinc	61721
2	Casing, E-GAS	M1023095
3	CPU BOARD, M-CAiOVX	8001806
4	Cover Plate for Gas Units	M1029000

Item	Description	Order No.
5	SCREW, machine screw, M3x18mm, DIN7985, ISO7045, Pozidrive, pan head, steel, zinc, STZn	61739
6	Air deflector M-CAiOV	886239
7	Filter Base, E-GAS	M1021041
8	M-CAiOV Fan	886213
9	Filler Plug, E-GAS	M1024364
10	Front Cover, DA, E-COV(X), E-CAiOV(X)	M1029150
10	Front Cover, DE, E-COV(X), E-CAiOV(X)	M1029151
10	Front Cover, EN, E-COV(X), E-CAiOV(X)	M1029152
10	Front Cover, ES, E-COV(X), E-CAiOV(X)	M1029153
10	Front Cover, FI, E-COV(X), E-CAiOV(X)	M1029154
10	Front Cover, FR, E-COV(X), E-CAiOV(X)	M1029155
10	Front Cover, HU, E-COV(X), E-CiAOV(X)	M1046325
10	Front Cover, IT, E-COV(X), E-CAiOV(X)	M1029156
10	Front Cover, JA, E-COV(X), E-CAiOV(X)	M1029157
10	Front Cover, NL, E-COV(X), E-CAiOV(X)	M1029158
10	Front Cover, NO, E-COV(X), E-CAiOV(X)	M1029159
10	Front Cover, PL, E-COV(X), E-CAiOV(X)	M1029160
10	Front Cover, PT, E-COV(X), E-CAiOV(X)	M1029161
10	Front Cover, SV, E-COV(X), E-CAiOV(X)	M1029162
10	Keyplate (no buttons), E-CO, E-CAiO	M1024362
11	Membrane Keyboard, E-GAS	M1024354
12	O-RING, O-RING, 4.0x1.0, NBR, SHORE 70	653125
13	O-ring, 2.8x1.6	65340
14	Ref. Gas Filter and Frame, E-CAIOV	M1028983
15	D-FEND water trap (replacement part), black	875055
15	D-FEND+ water trap (once), green	893200
16	SCREW, machine screw, M2.5x10mm, DIN7985, ISO7045, Pozidrive, pan head, steel	61715
17	Fan filter, E-CAiOV	M1028987
18	Latch	M1021039

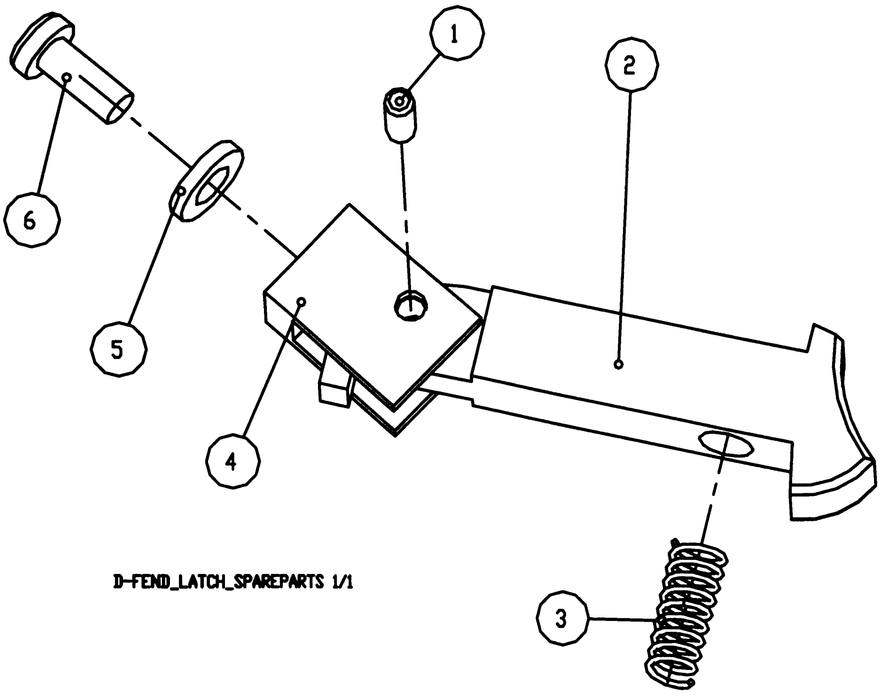
Item	**Description**	**Order No.**
19	Torsion Spring, E-REC, E-GAS	M1024356
20	Joint, E-GAS, Turned	M1023087
21	Front Panel Sticker, E-CAiO, DA (A, B, D)	M1035122
21	Front Panel Sticker, E-CAiO, DE (A, B, D)	M1035045
21	Front Panel Sticker, E-CAiO, EN (A, B, D)	M1031237
21	Front Panel Sticker, E-CAiO, ES (A, B, D)	M1035054
21	Front Panel Sticker, E-CAiO, FI (A, B, D)	M1035116
21	Front Panel Sticker, E-CAiO, FR (A, B, D)	M1035047
21	Front Panel Sticker, E-CAiO, HU (A, B, D)	M1042368
21	Front Panel Sticker, E-CAiO, IT (A, B, D)	M1035110
21	Front Panel Sticker, E-CAiO, JA (A, B, D)	M1035125
21	Front Panel Sticker, E-CAiO, NL (A, B, D)	M1035049
21	Front Panel Sticker, E-CAiO, NO (A, B, D)	M1035120
21	Front Panel Sticker, E-CAiO, PL (A, B, D)	M1035127
21	Front Panel Sticker, E-CAiO, PT (A, B, D)	M1035112
21	Front Panel Sticker, E-CAiO, SV (A, B, D)	M1035118
21	Front Panel Sticker, E-CAiOV, DA (A,B,C)	M1035840
21	Front Panel Sticker, E-CAiOV, DE (A,B,C)	M1035821
21	Front Panel Sticker, E-CAiOV, EN (A, B, C)	M1031245
21	Front Panel Sticker, E-CAiOV, ES (A,B,C)	M1035828
21	Front Panel Sticker, E-CAiOV, FI (A,B,C)	M1035834
21	Front Panel Sticker, E-CAiOV, FR (A,B,C)	M1035823
21	Front Panel Sticker, E-CAiOV, HU (A, B, D)	M1042371
21	Front Panel Sticker, E-CAiOV, IT (A,B,C)	M1035830
21	Front Panel Sticker, E-CAiOV, JA (A,B,C)	M1035842
21	Front Panel Sticker, E-CAiOV, NL (A,B,C)	M1035826
21	Front Panel Sticker, E-CAiOV, NO (A,B,C)	M1035838
21	Front Panel Sticker, E-CAiOV, PL (A,B,C)	M1035844
21	Front Panel Sticker, E-CAiOV, PT (A,B,C)	M1035832

Item	**Description**	**Order No.**
21	Front Panel Sticker, E-CAiOV, SV (A,B,C)	M1035836
21	Front Panel Sticker, E-CAiOVX, DA (A,B,C)	M1035943
21	Front Panel Sticker, E-CAiOVX, DE (A,B,C)	M1035921
21	Front Panel Sticker, E-CAiOVX, EN (A, B, C)	M1031248
21	Front Panel Sticker, E-CAiOVX, ES (A,B,C)	M1035928
21	Front Panel Sticker, E-CAiOVX, FI (A,B,C)	M1035936
21	Front Panel Sticker, E-CAiOVX, FR (A,B,C)	M1035924
21	Front Panel Sticker, E-CAiOVX, HU (A, B, D)	M1042375
21	Front Panel Sticker, E-CAiOVX, IT (A,B,C)	M1035930
21	Front Panel Sticker, E-CAiOVX, JA (A,B,C)	M1035945
21	Front Panel Sticker, E-CAiOVX, NL (A,B,C)	M1035926
21	Front Panel Sticker, E-CAiOVX, NO (A,B,C)	M1035941
21	Front Panel Sticker, E-CAiOVX, PL (A,B,C)	M1035947
21	Front Panel Sticker, E-CAiOVX, PT (A,B,C)	M1035934
21	Front Panel Sticker, E-CAiOVX, SV (A,B,C)	M1035938
21	Front Panel Sticker, E-CO, DA (A,B,D)	M1036193
21	Front Panel Sticker, E-CO, DE (A,B,D)	M1036169
21	Front Panel Sticker, E-CO, EN (A, B, D)	M1031240
21	Front Panel Sticker, E-CO, ES (A,B,D)	M1036179
21	Front Panel Sticker, E-CO, FI (A,B,D)	M1036186
21	Front Panel Sticker, E-CO, FR (A,B,D)	M1036172
21	Front Panel Sticker, E-CO, HU (A, B, D)	M1042377
21	Front Panel Sticker, E-CO, IT (A,B,D)	M1036181
21	Front Panel Sticker, E-CO, JA (A,B,D)	M1036196
21	Front Panel Sticker, E-CO, NL (A,B,D)	M1036175
21	Front Panel Sticker, E-CO, NO (A,B,D)	M1036190
21	Front Panel Sticker, E-CO, PL (A,B,D)	M1036200
21	Front Panel Sticker, E-CO, PT (A,B,D)	M1036184
21	Front Panel Sticker, E-CO, SV (A,B,D)	M1036188

Item	**Description**	**Order No.**
21	Front Panel Sticker, E-COV, (A,B,C), DE	M1036299
21	Front Panel Sticker, E-COV, DA (A,B,C)	M1036330
21	Front Panel Sticker, E-COV, EN (A, B, C)	M1029566
21	Front Panel Sticker, E-COV, ES (A,B,C)	M1036317
21	Front Panel Sticker, E-COV, FI (A,B,C)	M1036323
21	Front Panel Sticker, E-COV, FR (A,B,C)	M1036313
21	Front Panel Sticker, E-COV, HU (A, B, D)	M1042380
21	Front Panel Sticker, E-COV, IT (A,B,C)	M1036319
21	Front Panel Sticker, E-COV, JA (A,B,C)	M1036332
21	Front Panel Sticker, E-COV, NL (A,B,C)	M1036315
21	Front Panel Sticker, E-COV, NO (A,B,C)	M1036328
21	Front Panel Sticker, E-COV, PL (A,B,C)	M1036334
21	Front Panel Sticker, E-COV, PT (A,B,C)	M1036321
21	Front Panel Sticker, E-COV, SV (A,B,C)	M1036326
21	Front Panel Sticker, E-COVX, DA (A,B,C)	M1036440
21	Front Panel Sticker, E-COVX, DE (A,B,C)	M1036418
21	Front Panel Sticker, E-COVX, EN (A, B, C)	M1029575
21	Front Panel Sticker, E-COVX, ES (A,B,C)	M1036427
21	Front Panel Sticker, E-COVX, FI (A,B,C)	M1036433
21	Front Panel Sticker, E-COVX, FR (A,B,C)	M1036420
21	Front Panel Sticker, E-COVX, HU (A, B, D)	M1042382
21	Front Panel Sticker, E-COVX, IT (A,B,C)	M1036429
21	Front Panel Sticker, E-COVX, JA (A,B,C)	M1036443
21	Front Panel Sticker, E-COVX, NL (A,B,C)	M1036423
21	Front Panel Sticker, E-COVX, NO (A,B,C)	M1036437
21	Front Panel Sticker, E-COVX, PL (A,B,C)	M1036446
21	Front Panel Sticker, E-COVX, PT (A,B,C)	M1036431
21	Front Panel Sticker, E-COVX, SV (A,B,C)	M1036435
22	PVX Unit, E-CAiOV	M1029209

Item	Description	Order No.
23	PUMP, 0V, 10V, Air pump, max 0.39l/min, 10VDC, EPDM	57313
24	Zero absorber, M-Cxxx	895933

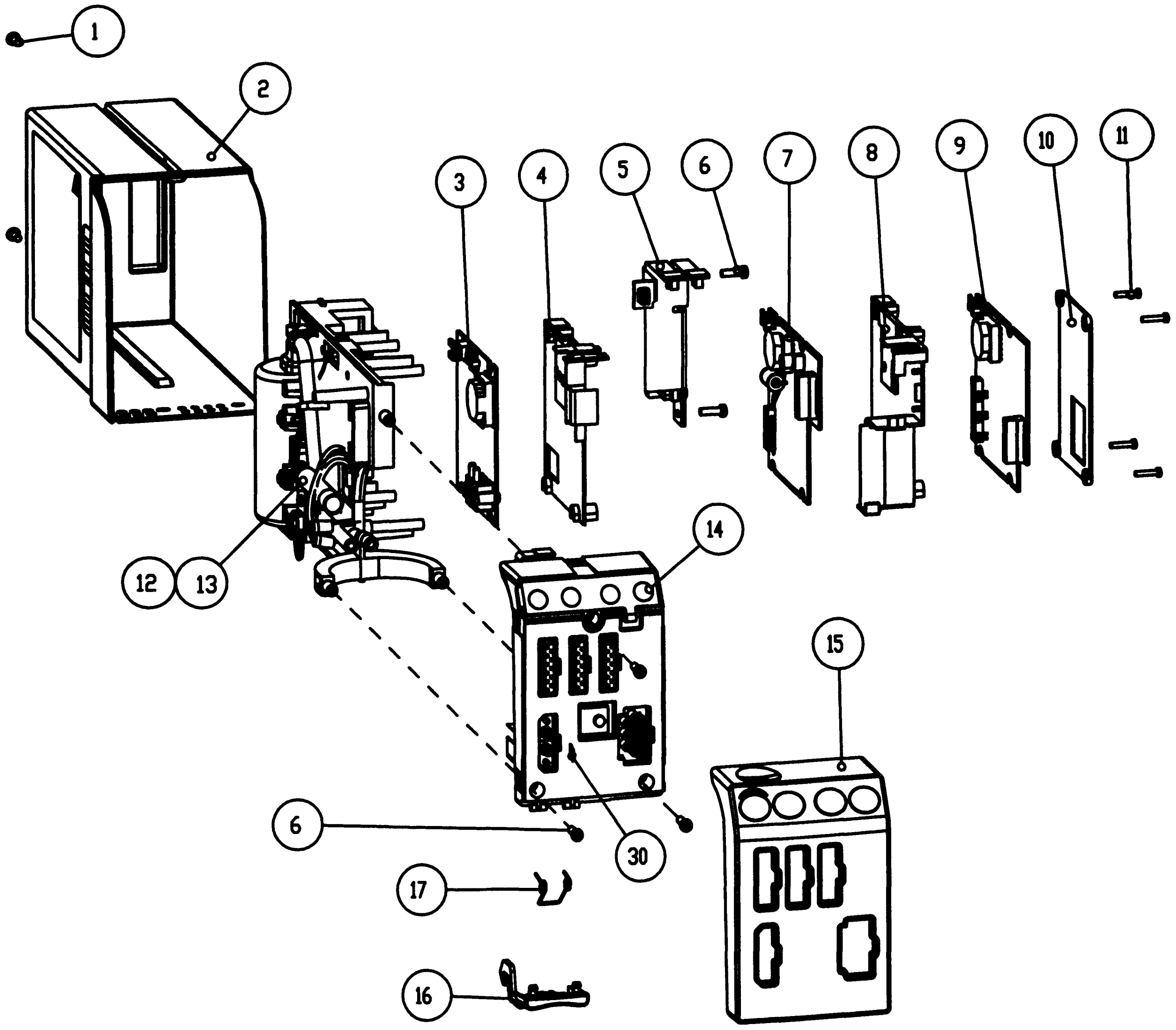
1.1 D-FEND latch



Item	Description	Order No.
	D-fend Latch Assembly, Spare Part Assembly	M1039037
1	Pin, M-CAiOV	887005
2	Latch, D-Fend	M1028985
3	Spring 0.4x2.5x10	64242
4	Hinge, M-CAiOV	886235
5	Washer STZN, M 2.7	63608
6	Screw M2.5x6 mm, DIN7985 ISO7045, Pozidrive	617120-HEL

2 Hemodynamic Modules

2.1 E-PRESTN

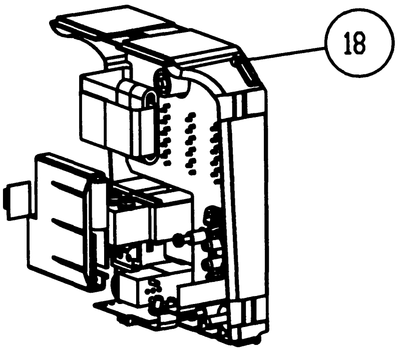


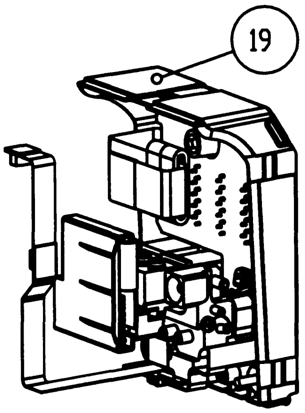
E-PRESTN_SPAREPARTS
1/2

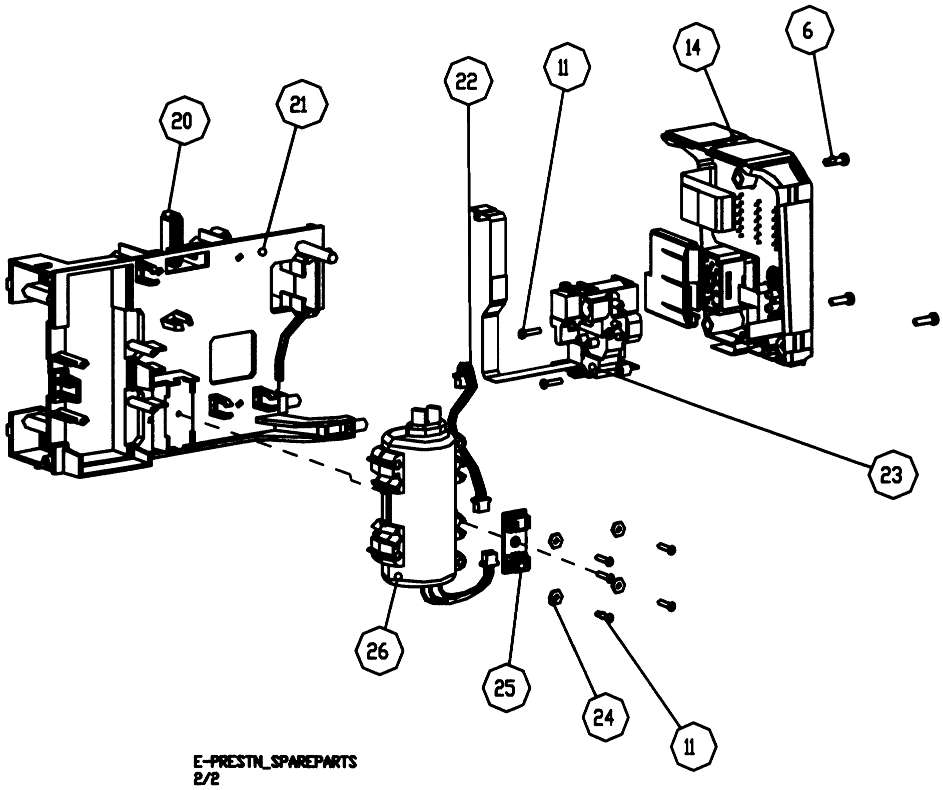
Item	Description	Order No.
1	SCREW, thread forming, M3x8mm, WN1423, torx head, flat countersunk head, steel	M1027118
2	Module Casing, Double	M1021037
3	NIBP Board PSM	M1007747
4	STP - NIBP insulator	M1008207
5	E-PRESTN Module bus connection board	M1024653
6	SCREW, for plastic PT, 3x10mm, WN1452, pan head, steel, zinc, head Torx 8, head max 5mm	628728

Item	Description	Order No.
7	STP-CO board, PSM	M1018406
8	ECG STP insulator	M1008205
9	ECG Board, PSM	M1007722
10	Board Cover, E-(P)RE(S)TN	M1038754
11	SCREW, PT, 2.2mmx10mm, torx head, pan head, steel	M1010187
12	FILTER, air filter, 30um, HDPE, D=6.5mm, d=3.3mm, L=46mm	57142
13	Filter cover	M1020996
14	Membrane Keyboard, E-(P)RE(S)TN	M1023085
15	Front Cover, DA, E-PRESTN	M1027792
15	Front Cover, DE, E-PRESTN	M1027793
15	Front Cover, EN, E-PRESTN	M1027794
15	Front Cover, ES, E-PRESTN	M1027795
15	Front Cover, FI, E-PRESTN	M1027796
15	Front Cover, HU, E-PRESTN	M1046280
15	Front Cover, IT, E-PRESTN	M1027797
15	Front Cover, JA, E-PRESTN	M1027798
15	Front Cover, FR, E-PRESTN	M1027799
15	Front Cover, NO, E-PRESTN	M1027801
15	Front Cover, NL, E-PRESTN	M1027800
15	Front Cover, PL, E-PRESTN	M1027802
15	Front Cover, PT, E-PRESTN	M1027803
15	Front Cover, SV, E-PRESTN	M1027804
15	Front Cover, DA, E-PRETN	M1027845
15	Front Cover, DE, E-PRETN	M1027846
15	Front Cover, EN, E-PRETN	M1027848
15	Front Cover, ES, E-PRETN	M1027851
15	Front Cover, FI, E-PRETN	M1027852
15	Front Cover, HU, E-PRETN	M1046282
15	Front Cover, IT, E-PRETN	M1027854
15	Front Cover, FR, E-PRETN	M1027853
15	Front Cover, JA, E-PRETN	M1027855
15	Front Cover, NL, E-PRETN	M1027856
15	Front Cover, PL, E-PRETN	M1027858

Item	Description	Order No.
15	Front Cover, NO, E-PRETN	M1027857
15	Front Cover, PT, E-PRETN	M1027859
15	Front Cover, SV, E-PRETN	M1027860
15	Front Cover, DA, E-RESTN	M1027866
15	Front Cover, DE, E-RESTN	M1027867
15	Front Cover, EN, E-RESTN	M1027868
15	Front Cover, ES, E-RESTN	M1027869
15	Front Cover, FI, E-RESTN	M1027870
15	Front Cover, FR, E-RESTN	M1027871
15	Front Cover, HU, E-RESTN	M1046289
15	Front Cover, IT, E-RESTN	M1027880
15	Front Cover, JA, E-RESTN	M1027881
15	Front Cover, NL, E-RESTN	M1027882
15	Front Cover, NO, E-RESTN	M1027883
15	Front Cover, PL, E-RESTN	M1027884
15	Front Cover, PT, E-RESTN	M1027885
15	Front Cover, SV, E-RESTN	M1027886
16	Latch	M1021039
17	Torsion Spring	M1020935
18	Front Chassis including connectors, E-(P)RE(S)TN, Spare Part	M1033420
19	Front Chassis Unit, E-PRESTN	M1027514



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E-PRESTN_SPAREPARTS
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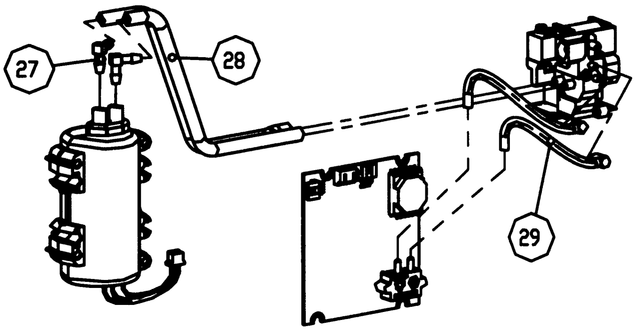
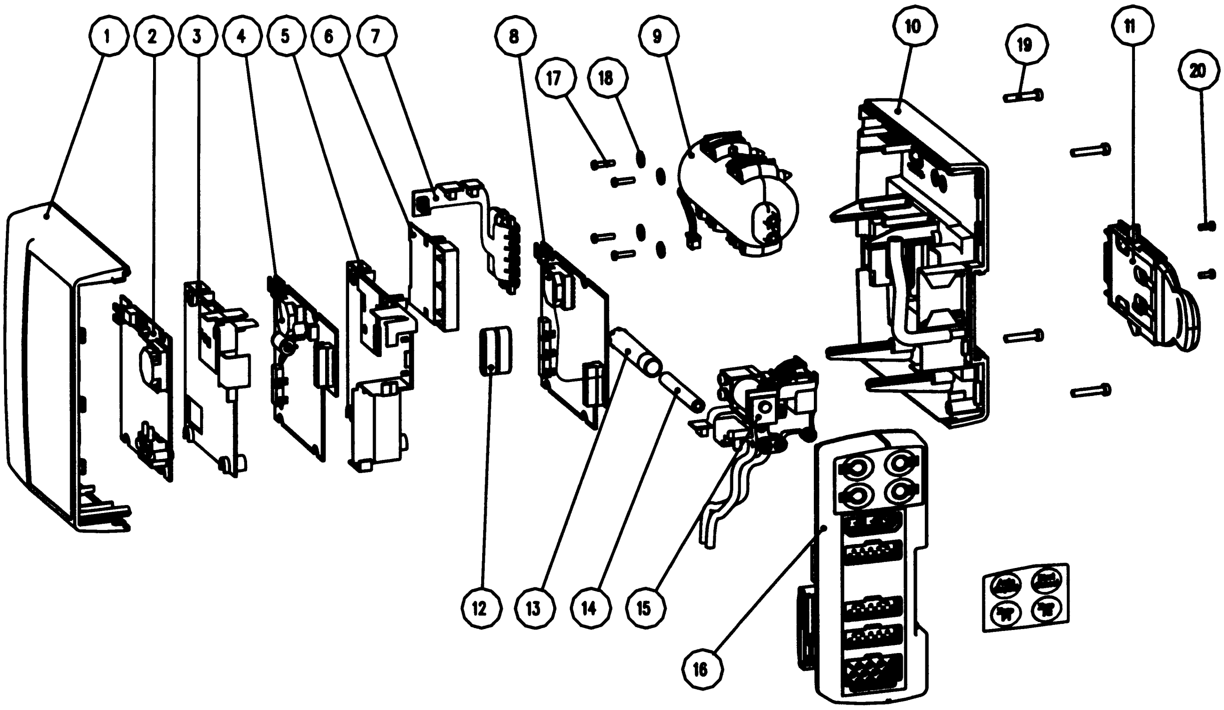


Item	**Description**	**Order No.**
20	FILT-EMI, low pass, soft ferrite for 16way flat cable, solid	304508
21	Frame, E-(P)RE(S)TN	M1023076
22	NIBP Pump Extension Wires, E-PRESTN	M1027664
23	NIBP Manifold Unit, E-PRESTN	M1027676
24	Washer 2.5x7.5x1 mm	M1010176
25	E-PRESTN NIBP pump connection board	M1024369
26	NIBP Pump Unit, E-PSM(P)	M1011858
27	Tube connector, L-piece 3mm, white	73381

28	Tube silicon 3,18x6,35	73375
29	Angled hose, E-(P)RE(S)TN	M1023083
30	Snap spring	M1036967

2.2 Patient Side Modules, E-PSM, E-PSMP



E-PSM(P) module

The following E-PSM(P) parts will be available as field replaceable spare parts:

Item	Description	Order No.
1	Cover, E-PSM(P)	M1021101
2	NIBP Board, E-PSM(P)	M1007747
3	STP NIBP Insulator, E-PSM(P)	M1008207
4	STP-CO Board, E-PSM(P)	M1018406
5	ECG STP Insulator, E-PSM(P)	M1008205
6	Module Bus Insulator, E-PSM(P)	M1007830
7	Module Flex Board Unit, E-PSM(P)	M1012191
8	ECG Board, E-PSM(P)	M1007722
9	NIBP Pump Unit, E-PSM(P)	M1011858
10	Frame, E-PSM(P)	M1008240
11	Lock Unit, E-PSM(P)	M1011862
12	EMI Filter, E-PSM(P)	M1007534
13	Filter Cover, E-PSM(P)	M1020996
14	Air Filter, E-PSM(P)	57142

Item	Description	Order No.
15	NIBP Manifold Unit, E-PSM(P)	M1020158
16	Front Panel Unit, E-PSM - DE	M1027533
16	Front Panel Unit, E-PSM - EN, NL, IT	M1027530
16	Front Panel Unit, E-PSM - ES	M1027534
16	Front Panel Unit, E-PSM - FI, DA, NO, PL, SV	M1027531
16	Front Panel Unit, E-PSM - FR, PT	M1027532
16	Front Panel Unit, E-PSM - HU	M1050791
16	Front Panel Unit, E-PSMP - DE	M1027524
16	Front Panel Unit, E-PSMP – EN, NL, IT	M1027528
16	Front Panel Unit, E-PSMP - ES	M1027529
16	Front Panel Unit, E-PSMP - FI, DA, NO, PL	M1027523
16	Front Panel Unit, E-PSMP - FR, PT	M1027525
16	Front Panel Unit, E-PSMP - HU	M1050790
16	Front Panel Unit, E-PSMP - SV	M1027526
	Screws and washers	
17	PT-screw 2.2x10 mm, TORX	M1010187
18	Washer 2.5x7.5x1 mm	M1010176
19	PT-screw 3x16 mm, TORX	M1000523
20	PT-screw 2.2x6 mm, TORX	M1010189

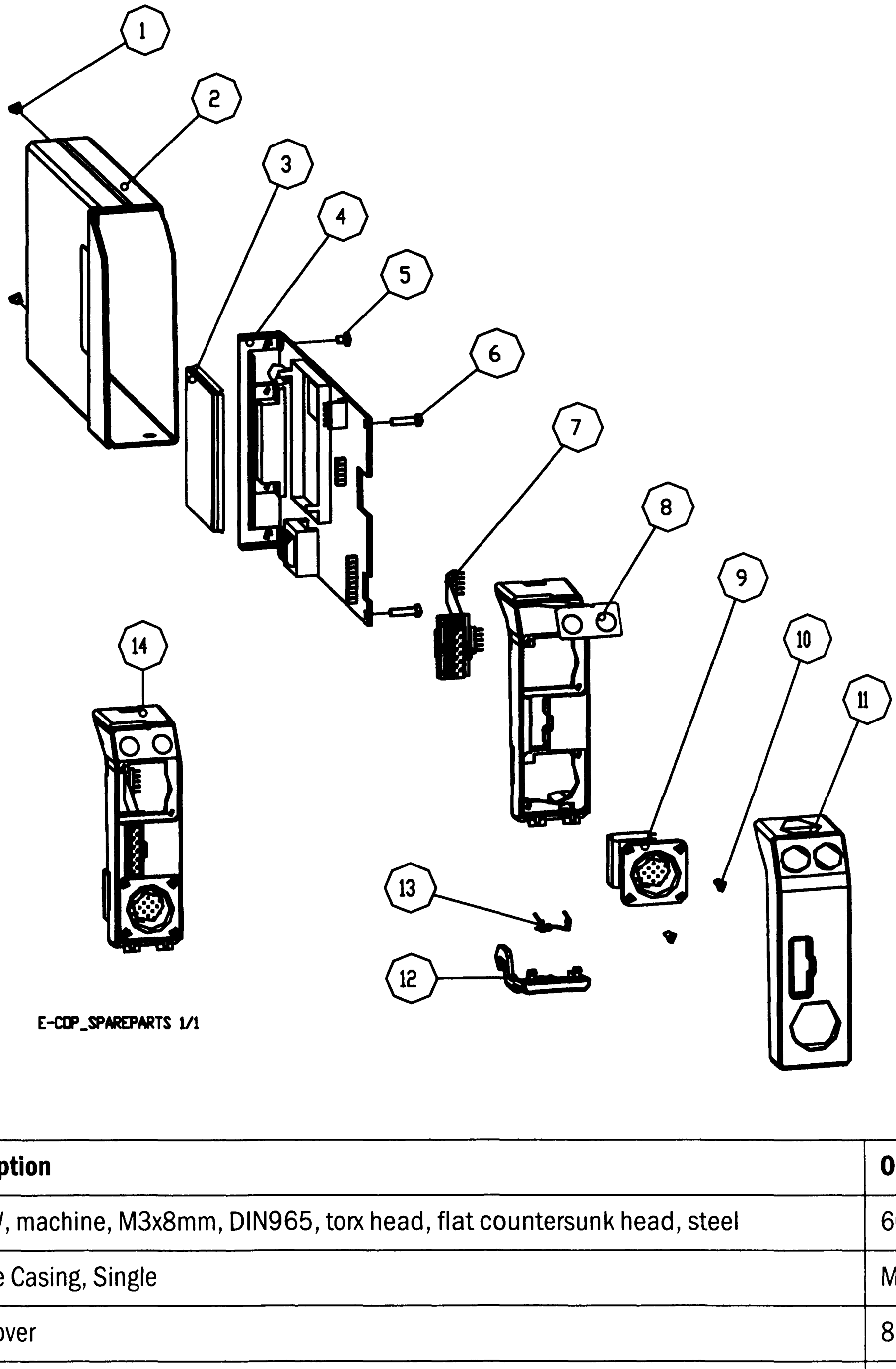
Front panel labeling, E-PSM(P)

Item	Description	Order No.
	Front Panel Sticker, E-PSM - DA	M1023749
	Front Panel Sticker, E-PSM - DE	M1023740
	Front Panel Sticker, E-PSM - EN	M1023739
	Front Panel Sticker, E-PSM - ES	M1023743
	Front Panel Sticker, E-PSM - FI	M1023746
	Front Panel Sticker, E-PSM - FR	M1023741
	Front Panel Sticker, E-PSM - HU	M1042359
	Front Panel Sticker, E-PSM - IT	M1023744
	Front Panel Sticker, E-PSM - NL	M1023742
	Front Panel Sticker, E-PSM - NO	M1023748
	Front Panel Sticker, E-PSM - PL	M1023750

Item	Description	Order No.
	Front Panel Sticker, E-PSM - PT	M1023745
	Front Panel Sticker, E-PSM - SV	M1023747
	Front Panel Sticker, E-PSMP - DA	M1021379
	Front Panel Sticker, E-PSMP - DE	M1021348
	Front Panel Sticker, E-PSMP - EN	M1020271
	Front Panel Sticker, E-PSMP - ES	M1021358
	Front Panel Sticker, E-PSMP - FR	M1021352
	Front Panel Sticker, E-PSMP - HU	M1042356
	Front Panel Sticker, E-PSMP - IT	M1021362
	Front Panel Sticker, E-PSMP - JA	M1021383
	Front Panel Sticker, E-PSMP - NL	M1021355
	Front Panel Sticker, E-PSMP - NO	M1021375
	Front Panel Sticker, E-PSMP - PL	M1021386
	Front Panel Sticker, E-PSMP - PT	M1021366
	Front Panel Sticker, E-PSMP - SV	M1021372

3 Cardiac Output Modules E-COP, E-COPSv

3.1 E-COP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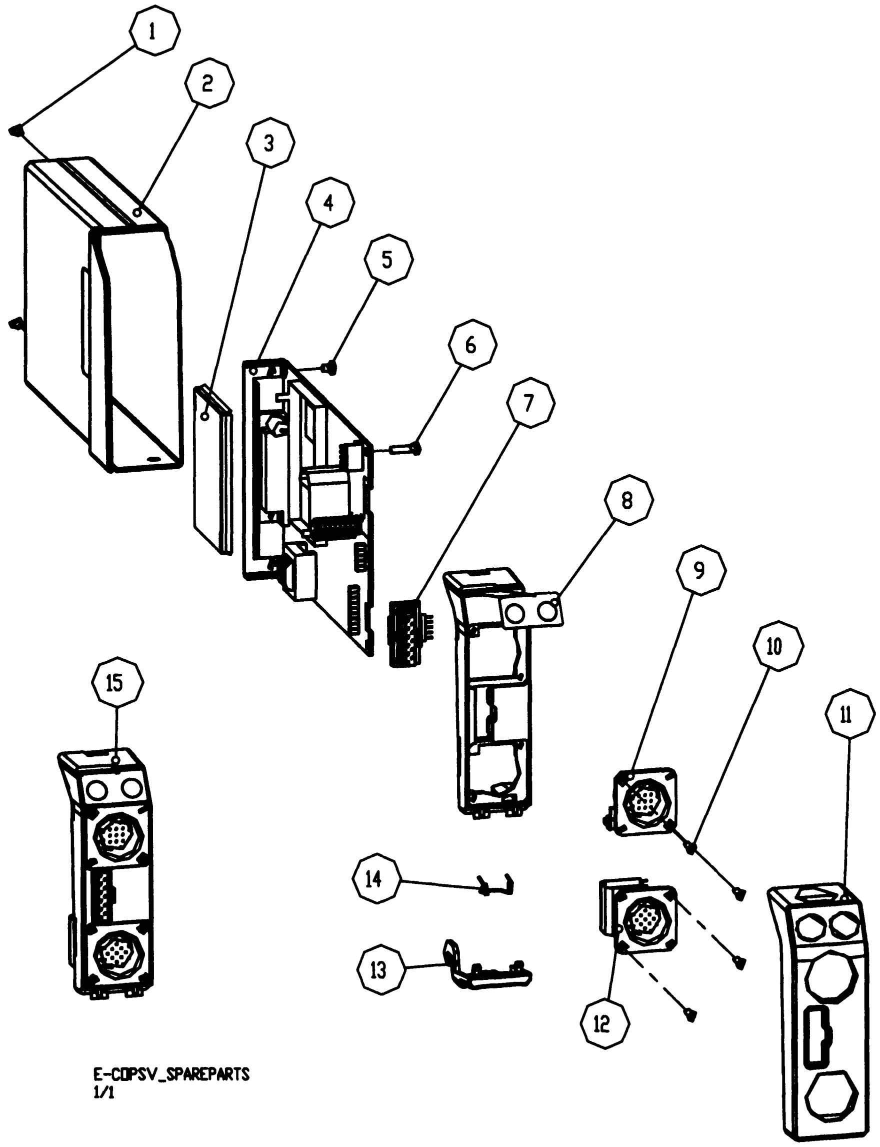
E-COP_SPAREPARTS 1/1

Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	EMC cover	884099
4	Metal frame	879184
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000

Item	Description	Order No.
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
7	Pressure input board, E-COPsV	M1021398
8	Membrane Keyboard	M1012126
9	CO Input Board, E-COP	M1025553
10	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318
11	Front Cover, DA, E-COP	M1025568
11	Front Cover, DE, E-COP	M1025569
11	Front Cover, EN, E-COP	M1025570
11	Front Cover, ES, E-COP	M1025571
11	Front Cover, FI, E-COP	M1025572
11	Front Cover, FR, E-COP	M1025573
11	Front Cover, HU, E-COP	M1046293
11	Front Cover, IT, E-COP	M1025574
11	Front Cover, JA, E-COP	M1025575
11	Front Cover, NL, E-COP	M1025576
11	Front Cover, NO, E-COP	M1025577
11	Front Cover, PL, E-COP	M1025578
11	Front Cover, PT, E-COP	M1025579
11	Front Cover, SV, E-COP	M1025580
12	Latch	M1021039
13	Torsion Spring	M1020935
14	Front Chassis Unit, E-COP	M1024291

3.2 E-COPSv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E-COPSV_SPAREPARTS
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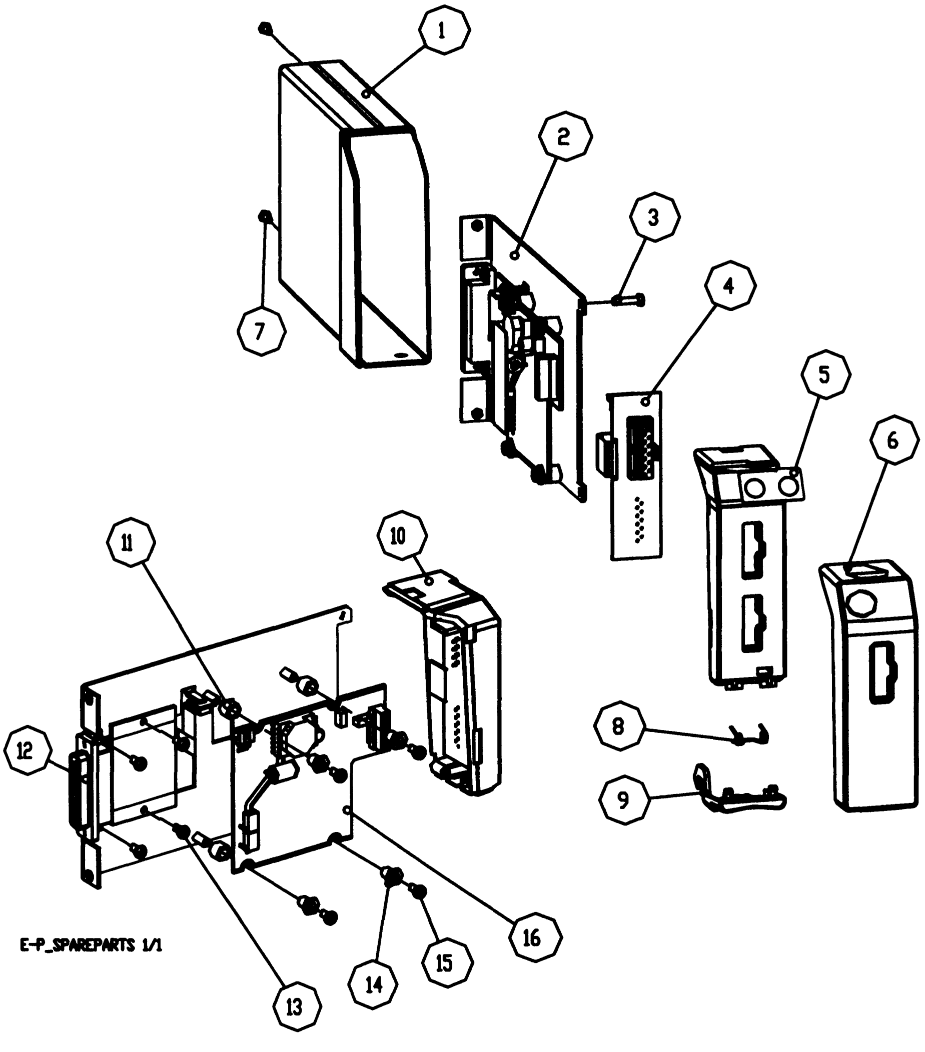
Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	EMC cover	884099
4	Metal frame	879184
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729

Item	Description	Order No.
7	Pressure input board, E-COPsV	M1021398
8	Membrane Keyboard	M1012126
9	SVO2 input board, E-COPsV	M1021397
10	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318
11	Front Cover Unit, DA, E-COPSV	M1027002
11	Front Cover Unit, DE, E-COPSV	M1027003
11	Front Cover Unit, EN, E-COPSV	M1027004
11	Front Cover Unit, ES, E-COPSV	M1027005
11	Front Cover Unit, FI, E-COPSV	M1027006
11	Front Cover Unit, FR, E-COPSV	M1027007
11	Front Cover Unit, HU, E-COPSV	M1046297
11	Front Cover Unit, IT, E-COPSV	M1027008
11	Front Cover Unit, JA, E-COPSV	M1027009
11	Front Cover Unit, NL, E-COPSV	M1027010
11	Front Cover Unit, NO, E-COPSV	M1027011
11	Front Cover Unit, PL, E-COPSV	M1027012
11	Front Cover Unit, PT, E-COPSV	M1027013
11	Front Cover Unit, SV, E-COPSV	M1027014
12	CO Input Board, E-COP	M1025553
13	Latch	M1021039
14	Torsion Spring	M1020935
15	Front Chassis Unit, E-COPSV	M1026573

4 Pressure Modules, E-P, E-PP, E-PT

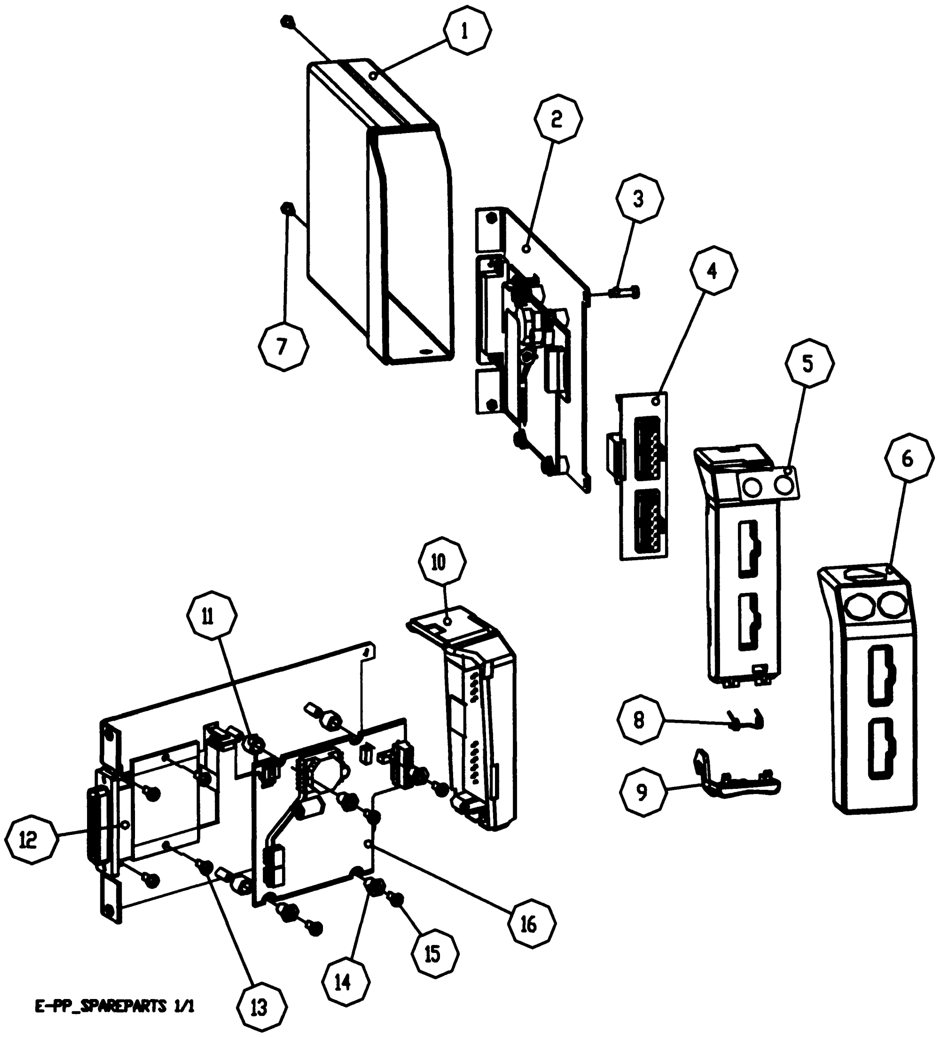
4.1 Pressure Module, E-P



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	E-P Input board	M1025766
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-P	M1027188
6	Front Cover, DE, E-P	M1027189
6	Front Cover, ES, E-P	M1027191

Item	Description	Order No.
6	Front Cover, EN, E-P	M1027190
6	Front Cover, FI, E-P	M1027192
6	Front Cover, HU, E-P	M1046310
6	Front Cover, IT, E-P	M1027194
6	Front Cover, FR, E-P	M1027193
6	Front Cover, JA, E-P	M1027195
6	Front Cover, NL, E-P	M1027196
6	Front Cover, NO, E-P	M1027197
6	Front Cover, PL, E-P	M1027198
6	Front Cover, PT, E-P	M1027199
6	Front Cover, SV, E-P	M1027200
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-P	M1027137
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PPand E-PT	M1024765

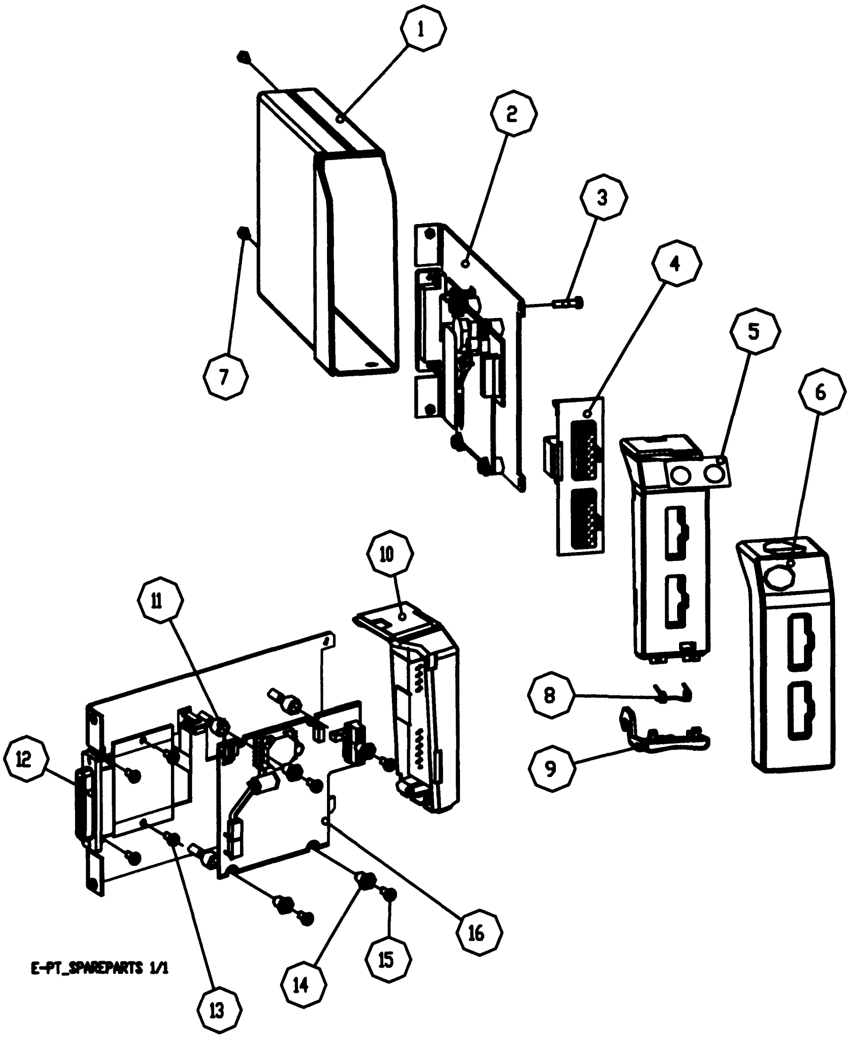
4.2 Dual Pressure Module, E-PP



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	E-PP Input board	M1022749
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-PP	M1027172
6	Front Cover, DE, E-PP	M1027173
6	Front Cover, EN, E-PP	M1027174
6	Front Cover, ES, E-PP	M1027175

Item	Description	Order No.
6	Front Cover, FI, E-PP	M1027176
6	Front Cover, FR, E-PP	M1027177
6	Front Cover, HU, E-PP	M1046274
6	Front Cover, IT, E-PP	M1027178
6	Front Cover, JA, E-PP	M1027179
6	Front Cover, NL, E-PP	M1027180
6	Front Cover, NO, E-PP	M1027181
6	Front Cover, PL, E-PP	M1027182
6	Front Cover, PT, E-PP	M1027183
6	Front Cover, SV, E-PP	M1027184
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-PP	M1027000
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PPand E-PT	M1024765

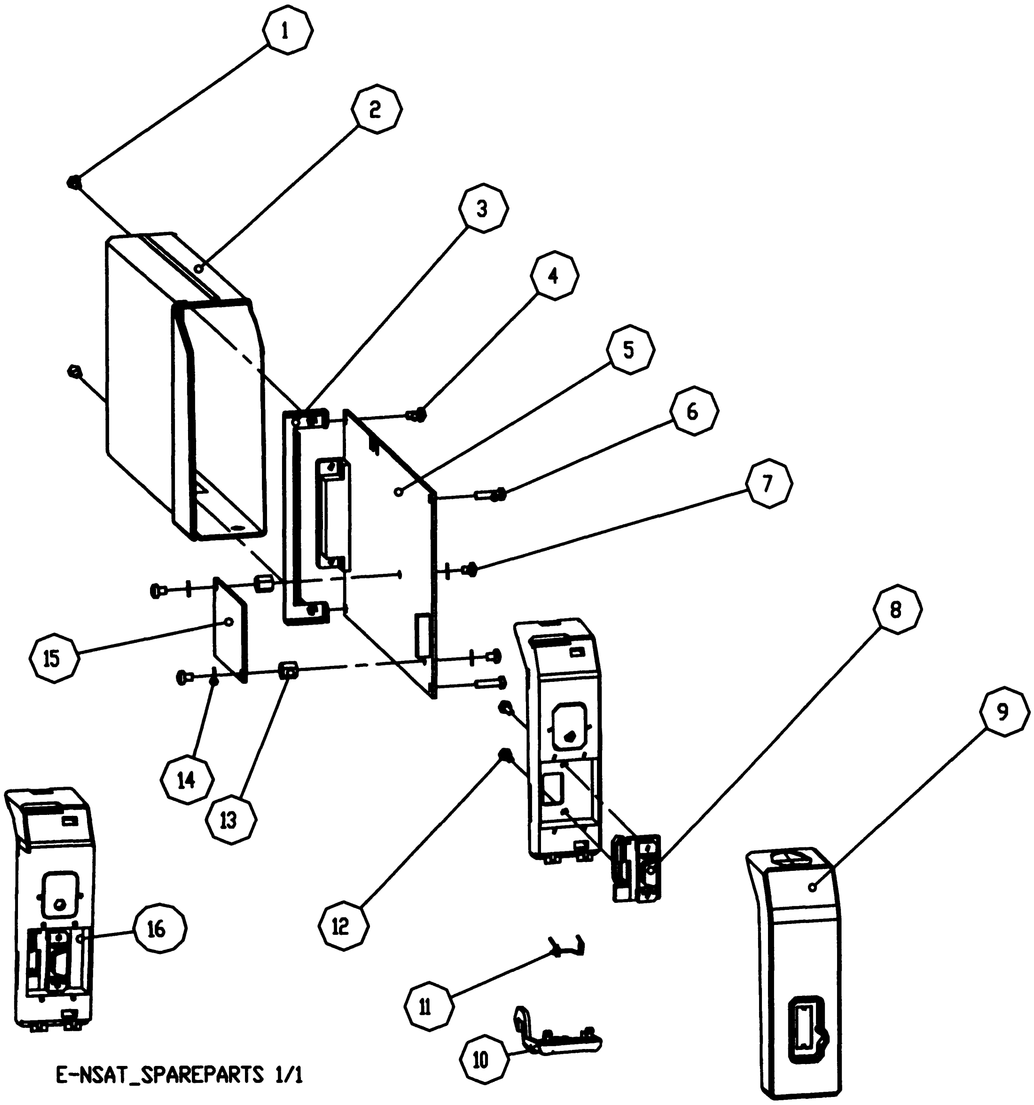
4.3 Pressure Temp Module, E-PT



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Body Plate, E-P, E-PP, E-PT	M1012033
3	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
4	Input board, E-PT	M1021461
5	Membrane Keyboard	M1012126
6	Front Cover, DA, E-PT	M1027157
6	Front Cover, DE, E-PT	M1027158
6	Front Cover, EN, E-PT	M1027159

Item	**Description**	**Order No.**
6	Front Cover, ES, E-PT	M1027160
6	Front Cover, FI, E-PT	M1027161
6	Front Cover, FR, E-PT	M1027162
6	Front Cover, HU, E-PT	M1046321
6	Front Cover, IT, E-PT	M1027163
6	Front Cover, JA, E-PT	M1027164
6	Front Cover, NL, E-PT	M1027165
6	Front Cover, NO, E-PT	M1027166
6	Front Cover, PL, E-PT	M1027167
6	Front Cover, PT, E-PT	M1027168
6	Front Cover, SV, E-PT	M1027169
7	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
8	Torsion Spring	M1020935
9	Latch	M1021039
10	Front Chassis Unit, E-PT	M1027140
11	Bushing, E-P, E-PT, E-PP	M103976
12	Module bus connection board for E-PT	M1021462
13	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000-HEL
14	Std Bushing nylon, D flange = 8.7 mm	M1046004
15	Screw	61123
16	STP Main Assembly for E-P, E-PPand E-PT	M1024765

5 Oxygen Saturation Module, E-NSAT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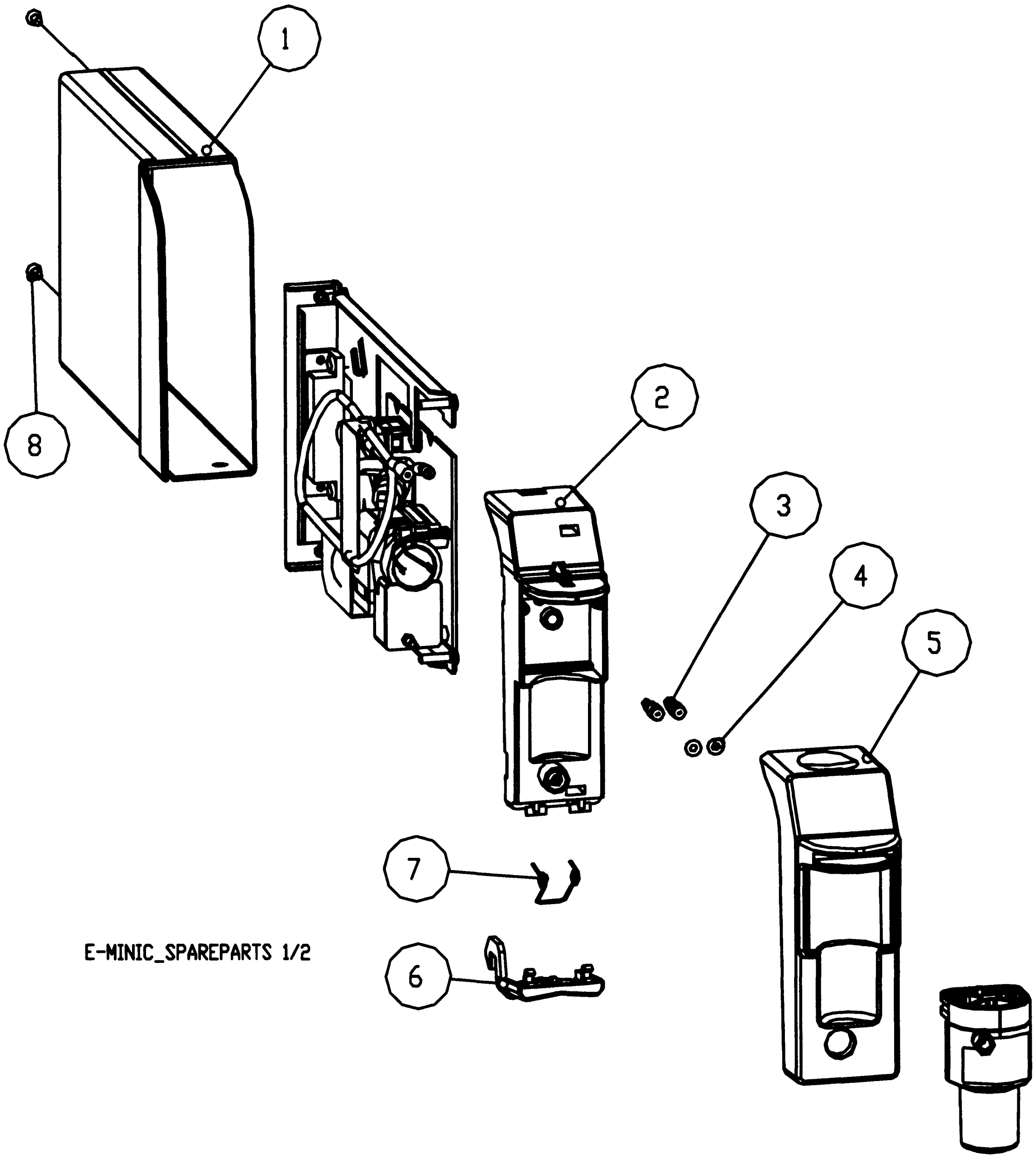
E-NSAT_SPAREPARTS 1/1

Item	Description	Order No.	Replaced
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single, Injection molded	M1021035	
3	Metal frame	879184	
4	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	61721	
5	Interface board E-NSAT for MP100, Printed Circuit Assembly	M1026771	

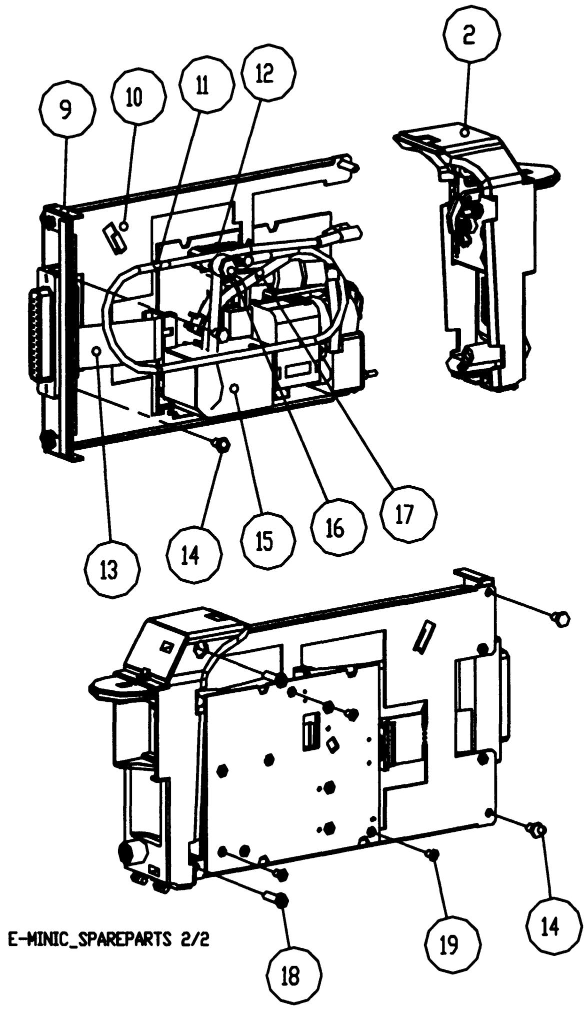
6	SCREW, screw for plastic,3.0 x12mm, torx head,	628729	
7	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel, zinc coated	M1025320	
8	E-NSAT flex board, Printed Circuit Assembly	M1035951	
9	Front Cover, EN, E-NSAT	M1024919	
9	Front Cover, DA, E-NSAT	M1025070	
9	Front Cover, DE, E-NSAT	M1025073	
9	Front Cover, ES, E-NSAT	M1025075	
9	Front Cover, FI, E-NSAT	M1025077	
9	Front Cover, HU, E-NSAT	M1046302	
9	Front Cover, IT, E-NSAT	M1025079	
9	Front Cover, FR, E-NSAT	M1025082	
9	Front Cover, NL, E-NSAT	M1025083	
9	Front Cover, NO, E-NSAT	M1025084	
9	Front Cover, JA, E-NSAT	M1025085	
9	Front Cover, PT, E-NSAT	M1025086	
9	Front Cover, SV, E-NSAT	M1025087	
10	Latch, Injection molded	M1021039	
11	Torsion Spring, Machined	M1020935	
12	SCREW, machine, M2.5x10mm, DIN7985, torx head, pan head, steel, zinc coated	M1026605	
13	M3 threaded hexagonal spacer, L 7mm, D max 5.5mm, brass	M1035473	
14	WASHER, 3.2x7.0x0.5mm, nylon-6 (PA-6), DIN125	M1028526	
15	Nellcor MP100 oximetry board	M1037711	
16	Front Chassis Unit, E-NSAT	M1025088	

6 Single-width Airway Module, E-miniC



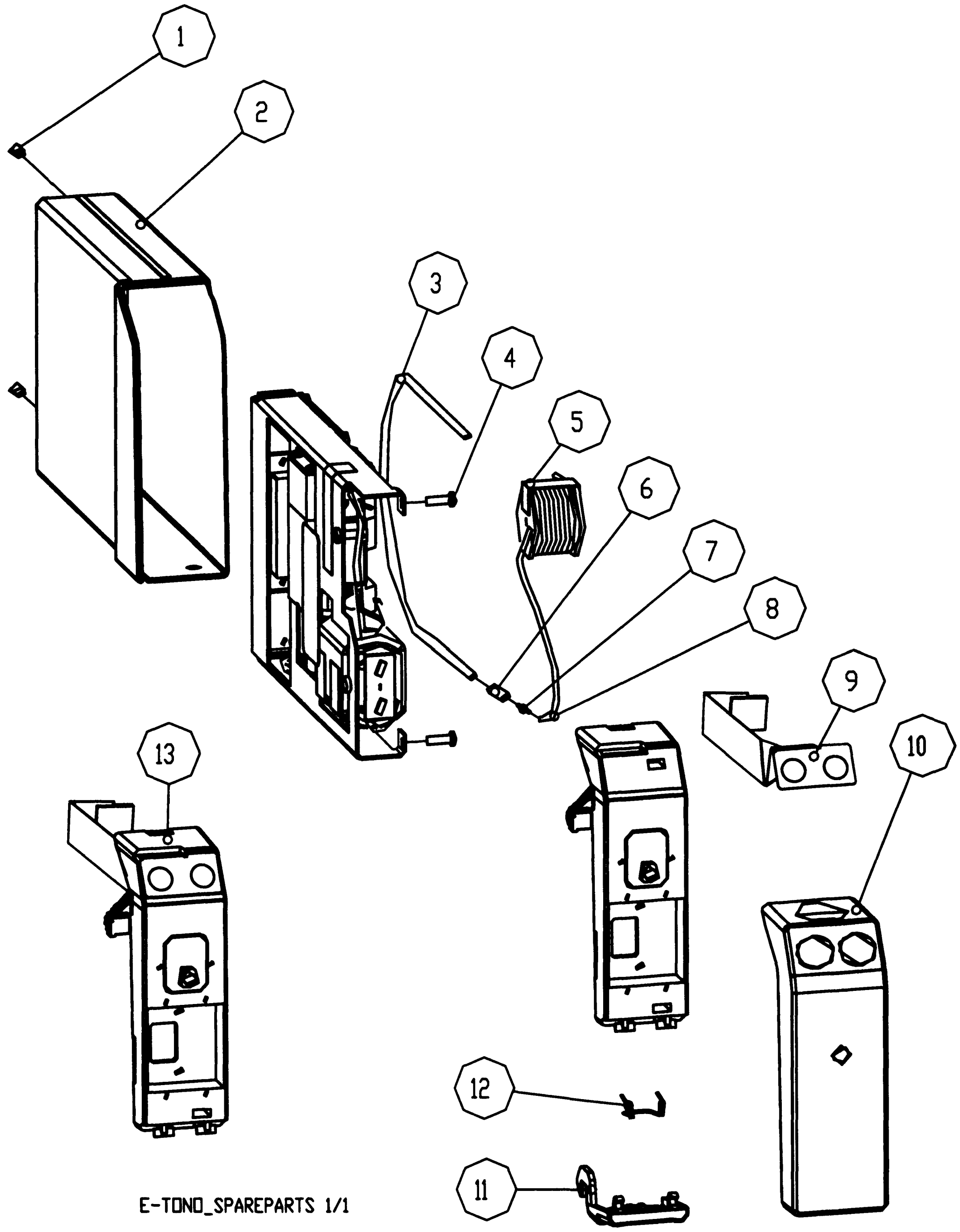
Item	Description	Order No.
	Mini D-Fend, pkg of 10 pcs	8002174
1	Module Casing, Single	M1021035
2	Front Chassis Unit, E-MINIC	M1027134
3	M-miniCO2, CONNECTOR FOR D-FEND, MINI CO2	8002173
4	O-RING, O-RING, 2.5x1.6, VITON, SHORE70, BLACK	656565
5	Front Cover, USA, E-MINIC	M1026941

Item	**Description**	**Order No.**
5	Front Cover, E-MINIC	M1026943
6	Latch	M1021039
7	Torsion Spring	M1020935
8	Screw-cross rec. c/s h, stzn, m3x6	61620



Item	**Description**	**Order No.**
9	Metal frame	879184
10	Frame, E-MINIC	M1024360
11	Nafion tubing 300mm	733382
12	MAGN-VALVE, N.O. valve, 3/2, 5VDC, 0.55W, includes seal	585714
13	Module Connection Flex, E-MINIC	M1027744
14	Cross cylinder head screw M3x6	61621
15	Pump Unit for miniC	M1013716
16	Air filter, M-MiniC	M1011471
17	Tubing Unit for miniC	M1013717
18	Cross cylinder head screw M3x10	628703
19	Screw-cross rec.c/s h,m3x8,acidproof	61609

7 Tonometry Module, E-TONO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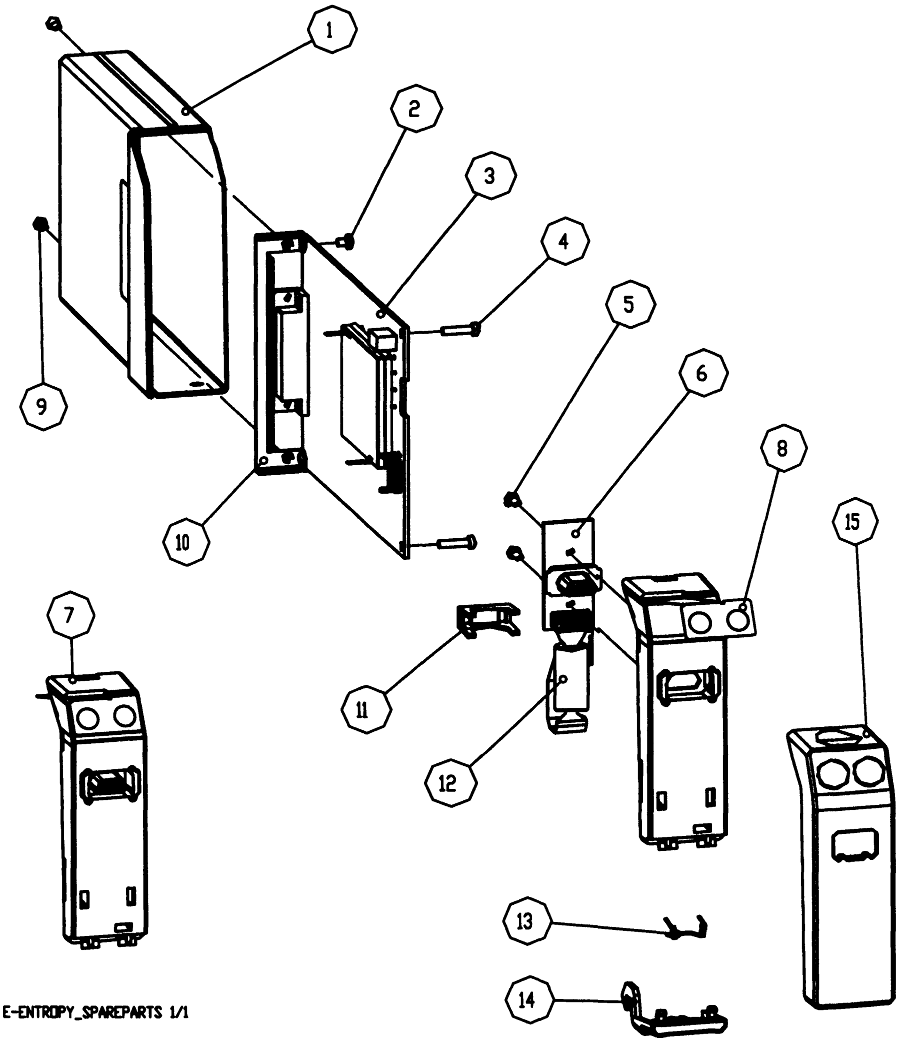
E-TONO_SPAREPARTS 1/1

Item	**Description**	**Order No.**
1	Screw-cross rec. c/s h, stzn, m3x6	61620
2	Module Casing, Single	M1021035
3	Nafion tubing 300mm	733382

Item	Description	Order No.
4	Cross cylinder head screw M3x10	628703
5	TUBE UNIT, M-TONO	896981
6	INSUL-TUBE, ID= 1.7 +/-0.2mm, Wall= 1.05 +/-0.2mm, SIK.8128	73373
7	Pipe 10mm	871925
8	Hose-plastic,d=2/hole 1,transluc.vin	73341
9	Membrane Keyboard, E-TONO	M1012121
10	Front Cover, DA, E-TONO	M1026193
10	Front Cover, DE, E-TONO	M1026196
10	Front Cover, EN, E-TONO	M1026197
10	Front Cover, ES, E-TONO	M1026198
10	Front Cover, FI, E-TONO	M1026199
10	Front Cover, FR, E-TONO	M1026201
10	Front Cover, HU, E-TONO	M1046314
10	Front Cover, IT, E-TONO	M1026202
10	Front Cover, JA, E-TONO	M1026203
10	Front Cover, NL, E-TONO	M1026204
10	Front Cover, NO, E-TONO	M1026206
10	Front Cover, PL, E-TONO	M1026207
10	Front Cover, PT, E-TONO	M1026208
10	Front Cover, SV, E-TONO	M1026209
11	Latch	M1021039
12	Torsion Spring	M1020935
13	Front Chassis Unit, E-TONO	M1026527

8 Entropy Module, E-ENTROPY

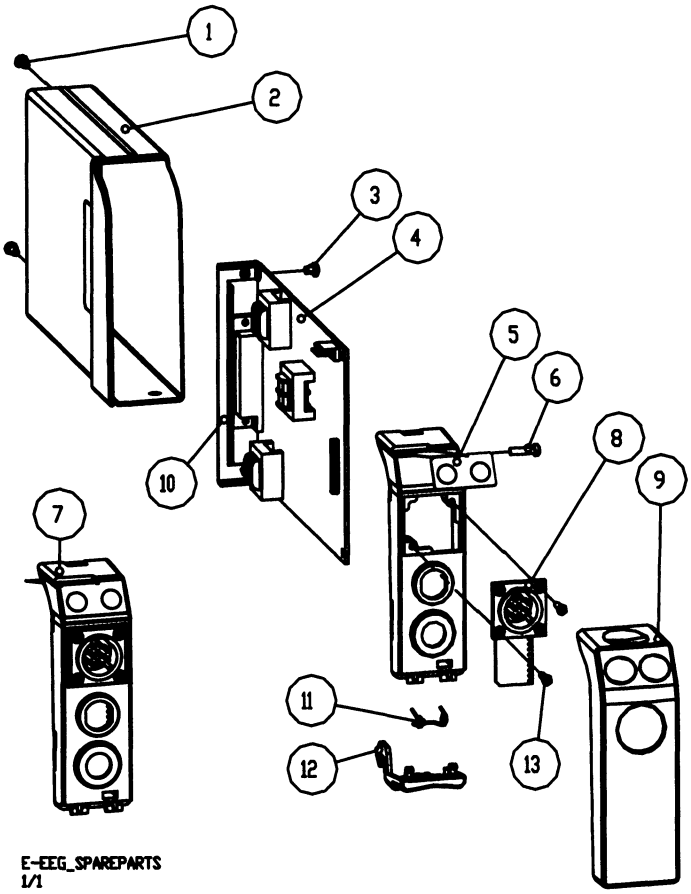


Item	Description	Order No.
1	Module Casing, Single	M1021035
2	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel	M1025320
3	Entropy Board, M-ENTROPY	8004787
4	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
5	SCREW, screw for plastic, x8mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x8mm, ST-ZN, WN1452	628727
6	IMC CONNECTOR BOARD, M-ENTROPY	8004791
7	Front Chassis Unit, E-ENTROPY	M1024285

Item	**Description**	**Order No.**
8	Membrane Keyboard	M1012126
9	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
10	Metal frame	879184
11	Ferrite holder, M-ENTROPY, Investment cast	M1002842
12	CONNECTOR CABLE, M-ENTROPY..01	8005305
13	Torsion Spring	M1020935
14	Latch	M1021039
15	Front Cover, EN, E-ENTROPY	M1021097
15	Front Cover, DA, E-ENTROPY	M1024882
15	Front Cover, ES, E-ENTROPY	M1024939
15	Front Cover, FI, E-ENTROPY	M1024941
15	Front Cover, FR, E-ENTROPY	M1024942
15	Front Cover, HU, E-ENTROPY	M1046108
15	Front Cover, IT, E-ENTROPY	M1024943
15	Front Cover, JA, E-ENTROPY	M1024944
15	Front Cover, NL, E-ENTROPY	M1024945
15	Front Cover, NO, E-ENTROPY	M1024946
15	Front Cover, PL, E-ENTROPY	M1024947
15	Front Cover, PT, E-ENTROPY	M1024948
15	Front Cover, SV, E-ENTROPY	M1024949
15	Front Cover, DE, E-ENTROPY	M1020825

9 EEG Module and EEG Headbox

9.1 EEG Module, E-EEG



Item	Description	Order No.	Replaced by
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel, zinc coated	606024	
2	Module Casing, Single, Injection molded	M1021035	
3	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	61721	
4	NEURO BOARD, M-EEG, Printed Circuit Assembly	898806	
5	Membrane Keyboard, Sheet metal	M1012126	
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628700	
7	Front Chassis Unit, E-EEG, Manufacturing assembly	M1025223	
8	EEG Input board, E-EEG, Printed Circuit Assembly	M1021394	

Item	Description	Order No.	Replaced by
9	Front Cover, DE, E-EEG	M1025171	
9	Front Cover, EN, E-EEG	M1025172	
9	Front Cover, ES, E-EEG	M1025173	
9	Front Cover, FI, E-EEG	M1025174	
9	Front Cover, FR, E-EEG	M1025175	
9	Front Cover, HU, E-EEG	M1046299	
9	Front Cover, JA, E-EEG	M1025177	
9	Front Cover, NL, E-EEG	M1025178	
9	Front Cover, NO, E-EEG	M1025180	
9	Front Cover, PL, E-EEG	M1025181	
9	Front Cover, PT, E-EEG	M1025182	
9	Front Cover, SV, E-EEG	M1025183	
10	Metal frame	879184	
11	Torsion Spring, Machined	M1020935	
12	Latch, Injection molded	M1021039	
13	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel, zinc coated	M1025318	

9.2 EEG Headbox, N-EEG rev. 00, 01

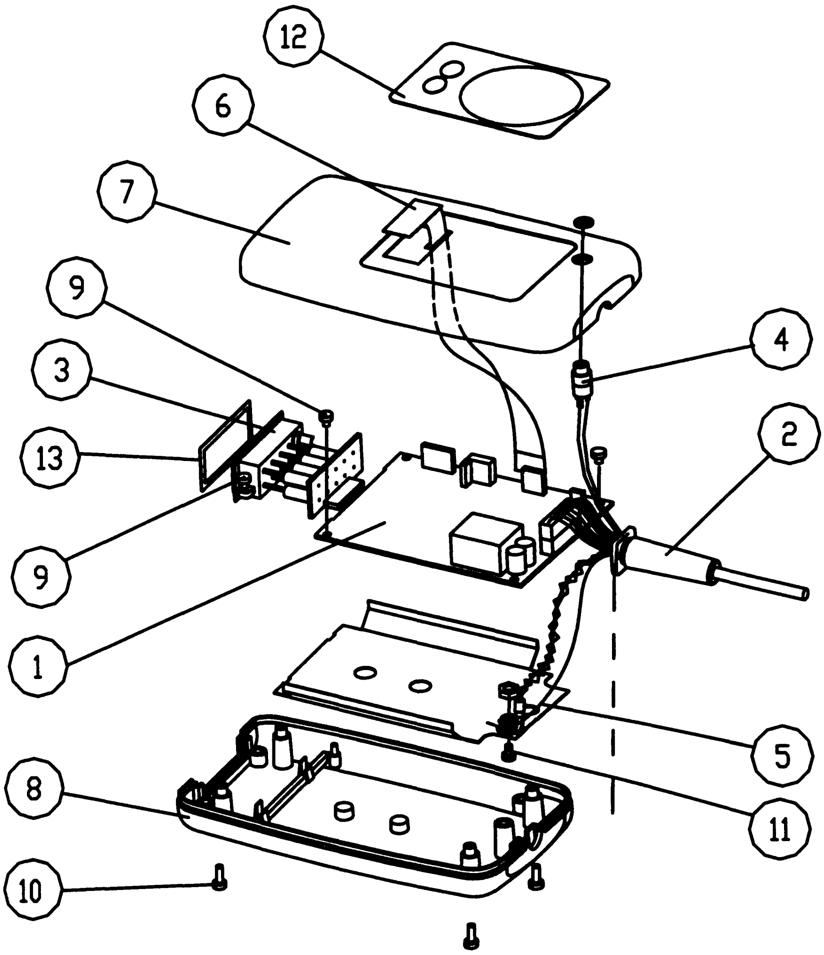


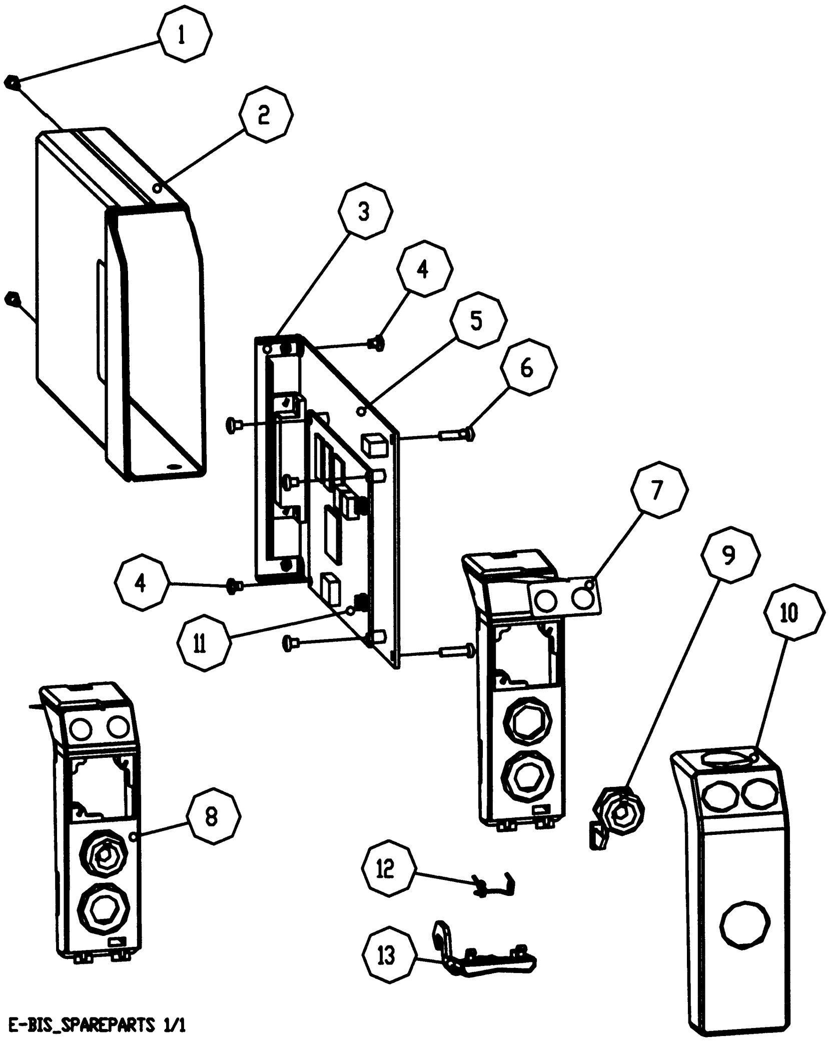
Figure 1 **Exploded view of headbox**

Item	Description	Order No.	Replaced by
1	EEG headbox board, N-EEG	898805	
2	Module-headbox cable, N-EEG	895610	
3	Headbox input unit	896558	
4	AEP-connector, N-EEG	896461	895610
5	EMC cover	898276	
6	Membrane keypad	880101	
7	Cover	896457	
8	Bottom side of N-EEG	896557	
9	Cross cyl. head screw M3x6	61515	
10	Cross cylinder head screw M3x12	61736	

Item	Description	Order No.	Replaced by
11	Cross cylinder head screw M3x12 zinc-coated	61721	
12	Front Panel sticker, DA; N-EEG (rev.01); S/5	898708	
12	Front Panel sticker, DE; N-EEG (rev.01); S/5	898699	
12	Front Panel sticker, EN; N-EEG (rev.01); S/5	898698	
12	Front Panel sticker, ES; N-EEG (rev.01); S/5	898702	
12	Front Panel sticker, FI; N-EEG (rev.01); S/5	898705	
12	Front Panel sticker, FR; N-EEG (rev.01); S/5	898700	
12	Front Panel sticker, IT; N-EEG (rev.01); S/5	898703	
12	Front Panel sticker, HU; N-EEG (rev.01); S/5	M1042346	
12	Front Panel sticker, JA; N-EEG (rev.01); S/5	8000382	
12	Front Panel sticker, NL; N-EEG (rev.01); S/5	898701	
12	Front Panel sticker, NO; N-EEG (rev.01); S/5	898707	
12	Front Panel sticker, PT; N-EEG (rev.01); S/5	898704	
12	Front Panel sticker, SV; N-EEG (rev.01); S/5	898706	
12	Headbox sticker, DA; N-EEG (rev.00)	897266	
12	Headbox sticker, DE; N-EEG (rev.00)	897267	
12	Headbox sticker, EN; N-EEG (rev.00)	896512	
12	Headbox sticker, ES; N-EEG (rev.00)	897268	
12	Headbox sticker, FI; N-EEG (rev.00)	897269	
12	Headbox sticker, FR; N-EEG (rev.00)	897270	
12	Headbox sticker, IT; N-EEG (rev.00)	897271	
12	Headbox sticker, NL; N-EEG (rev.00)	897272	
12	Headbox sticker, NO; N-EEG (rev.00)	897273	
12	Headbox sticker, PT; N-EEG (rev.00)	897274	
12	Headbox sticker, SV N-EEG (rev.00)	897275	
13	Electrode sticker, DA; N-EEG (rev.01); S/5	898207	
13	Electrode sticker, DE, EN, FI,; N-EEG (rev.01); S/5	897858	
13	Electrode sticker, ES; N-EEG (rev.01); S/5	898203	
13	Electrode sticker, FR; N-EEG (rev.01); S/5	898201	
13	Electrode sticker, HU; N-EEG (rev.01); S/5	M1042351	
13	Electrode sticker, IT; N-EEG (rev.01); S/5	898204	
13	Electrode sticker, JA; N-EEG (rev.01); S/5	8000393	
13	Electrode sticker, NL; N-EEG (rev.01); S/5	898202	

Item	Description	Order No.	Replaced by
13	Electrode sticker, NO; N-EEG (rev.01); S/5	898208	
13	Electrode sticker, PT; N-EEG (rev.01); S/5	898205	
13	Electrode sticker, SV; N-EEG (rev.01); S/5	898206	

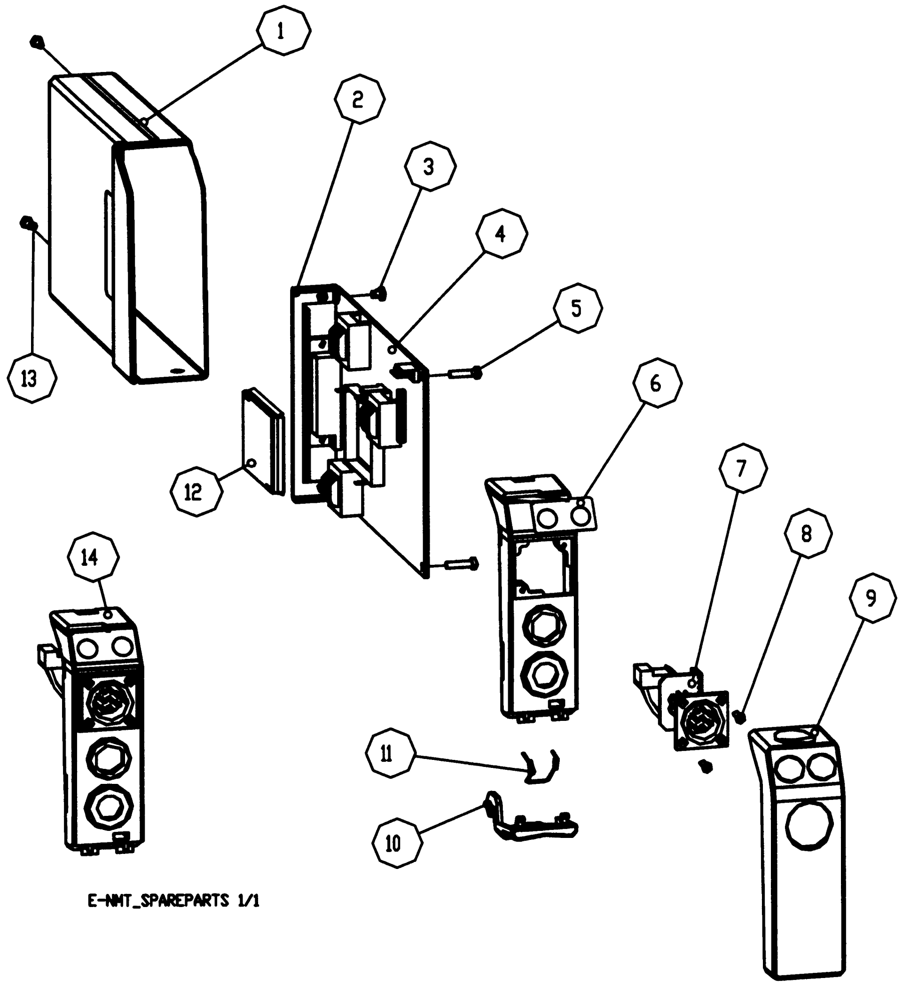
10 BIS Module, E-BIS



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	Metal frame	879184
4	SCREW, machine, M3x4mm, DIN7985, torx head, pan head, steel	M1025320
5	Interface Board, M-BIS, Product assembly	M1029851
6	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
7	Membrane Keyboard	M1012126
8	Front Chassis Unit, E-BIS	M1024772
9	BIS CONNECTOR UNIT, M-BIS	8002480

Item	**Description**	**Order No.**
10	Front Cover,DA, E-BIS	M1024768
10	Front Cover, ES, E-BIS	M1024915
10	Front Cover, DE, E-BIS	M1024924
10	Front Cover, EN, E-BIS	M1024925
10	Front Cover, FI, E-BIS	M1024926
10	Front Cover, FR, E-BIS	M1024928
10	Front Cover, HU, E-BIS	M1046286
10	Front Cover, IT, E-BIS	M1024929
10	Front Cover, JA, E-BIS	M1024930
10	Front Cover, NL, E-BIS	M1024931
10	Front Cover, NO, E-BIS	M1024932
10	Front Cover, PL, E-BIS	M1024933
10	Front Cover, PT, E-BIS	M1024934
10	Front Cover, SV, E-BIS	M1024935
11	OEM-ITEM, BIS-Engine Board, BIS-Engine Board	900505
12	Torsion Spring	M1020935
13	Latch	M1021039

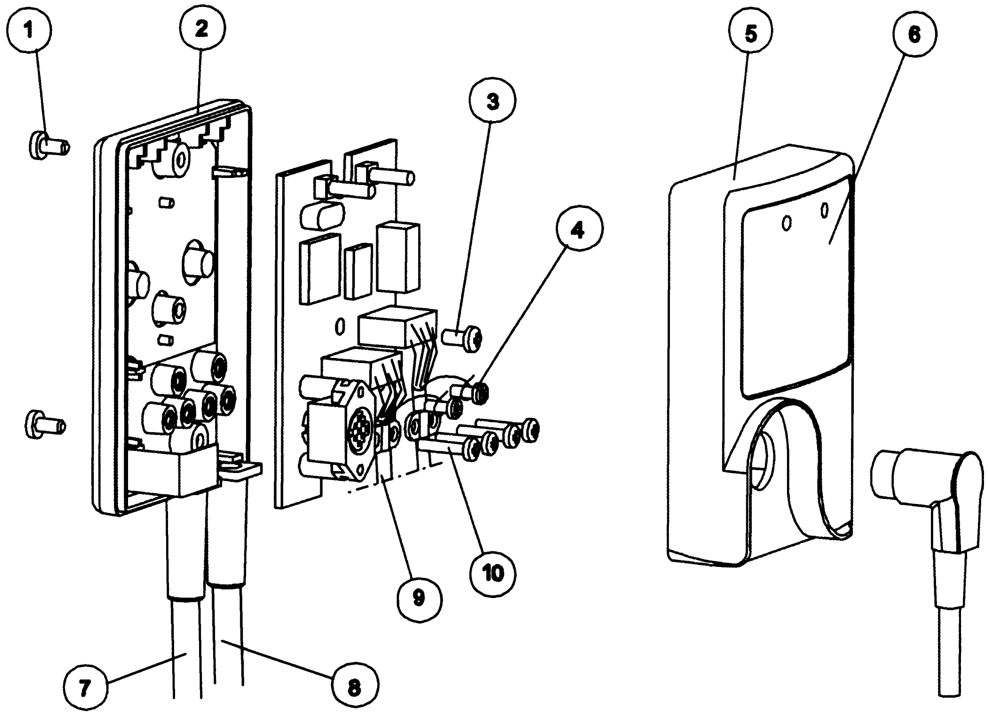
11 NMT Module, E-NMT



Item	Description	Order No.
1	Module Casing, Single	M1021035
2	Metal frame	879184
3	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
4	NMT BOARD, M-NMT	887487
5	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
6	Membrane Keyboard	M1012126
7	NMT Connector Board, E-NMT	M1024116
8	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318

Item	**Description**	**Order No.**
9	Front Cover, DE, E-NMT	M1025669
9	Front Cover, EN, E-NMT	M1025671
9	Front Cover, ES, E-NMT	M1025672
9	Front Cover, FI, E-NMT	M1025673
9	Front Cover, FR, E-NMT	M1025674
9	Front Cover, HU, E-NMT	M1046307
9	Front Cover, IT, E-NMT	M1025675
9	Front Cover, JA, E-NMT	M1025676
9	Front Cover, NL, E-NMT	M1025677
9	Front Cover, NO, E-NMT	M1025678
9	Front Cover, PL, E-NMT	M1025679
9	Front Cover, PT, E-NMT	M1025680
9	Front Cover, SV, E-NMT	M1025681
9	Front Cover, DA, E-NMT	M1024266
10	Latch	M1021039
11	Torsion Spring	M1020935
12	EMC cover	886320
13	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
14	Front Chassis Unit, E-NMT	M1024188

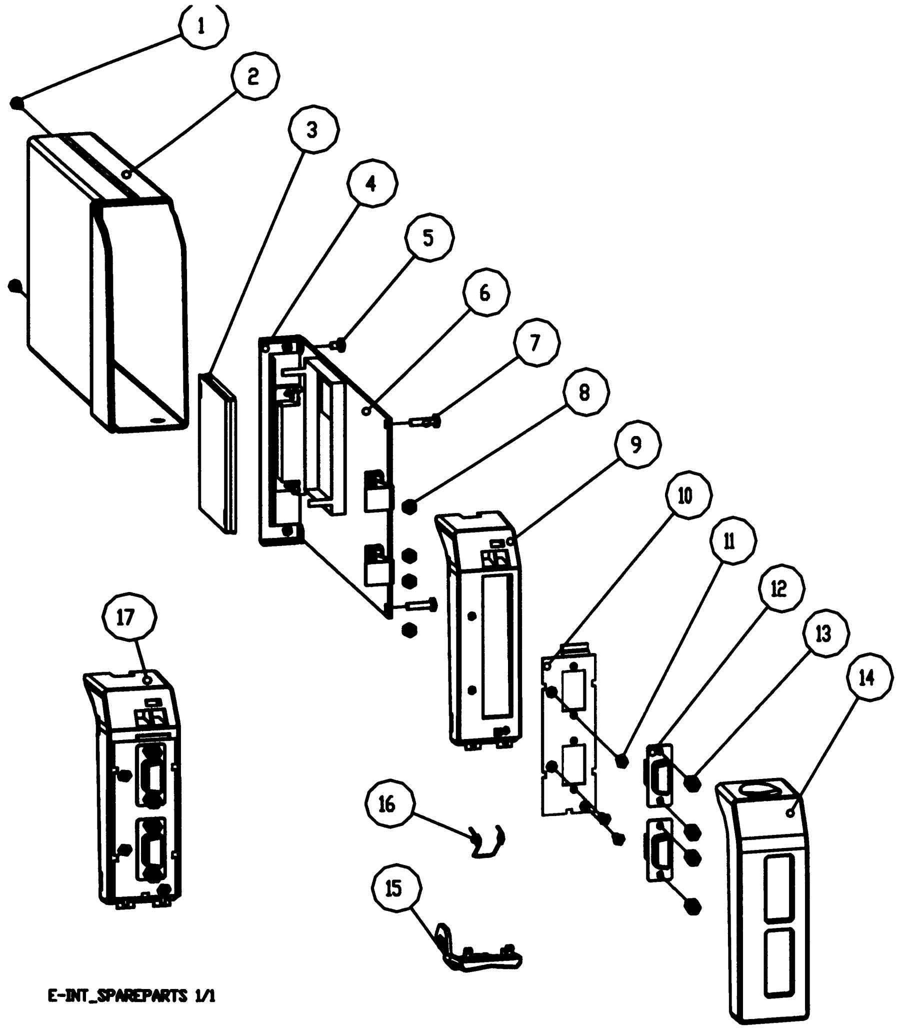
12 Device Interfacing Solution, N-DISxxx



Item	Description		Order No.
1	Screw for the DIS module case		617210
2	DIS module case, rear		896930
3	Screw for the PC board		61209
4	Screw for cable		617120
5	DIS module case, front		896929
7	Bus cable, 1 m		900501
7	Bus cable, 2 m		900502
7	Bus cable, 6 m		900503
	Labels for module case:		
6	Label for Abbot Q-Vue/Q2	N-DISQVUE	897210
6	Label for AVL Opticca	N-DISOPT	897543
6	Label for Abbot Oximetrix 3	N-DISOXIM3	8000983
6	Label for Baxter Vigilance	N-DISVIGIL	8002434

Item	**Description**		**Order No.**
6	Label for Dräger Evita 4 Ventilator	N-DISEV4	897193
6	Label for Aspect A-2000 EEG Monitor	N-DISA2000	897194
6	Label for Datex-Ohmeda 5250 RGM Monitor	N-DISRGM	897195
6	Label for Jostra HL-20 Perfusion Machine	N-DISHL20	897196
6	Label for Nellcor P-B 7200	N-DIS7200	897207
6	Label for Nellcor P-B 840	N-DIS840	8002435
6	Label for Datex-Ohmeda Aestiva/5	N-DISAEST	8002595
6	Label for Datex-Ohmeda Tonocap	N-DISTONO	897209
6	Label for Datex-Ohmeda Smartvent 7900	N-DIS7900	8002598
6	Label for Siemens Servo	N-DISS300	8000392
6	Label for Datex-Ohmeda whiteline monitors	N-DISWHITE	8000405
6	Label for x-Ohmada Carestation	N-DISVENT	M1023408
	Device specific cables:		
8	Cable for Abbot Q-Vue/Q2	N-DISQVUE	897230
8	Cable for AVL Opticca	N-DISOPT	897544
8	Cable for Abbot Oximetrix 3	N-DISOXIM3	8002839
8	Cable for Baxter Vigilance	N-DISVIGIL	8002841
8	Cable for Dräger Evita 4 Ventilator	N-DISEV4	897213
8	Cable for Aspect A-2000 EEG Monitor	N-DISA2000	897214
8	Cable for Datex-Ohmeda 5250 RGM Monitor	N-DISRGM	897215
8	Cable for Jostra HL20 Perfusion Machine	N-DISHL20	897216
8	Cable for Nellcor P-B 7200	N-DIS7200	897227
8	Cable for Nellcor P-B 840	N-DIS840	8002481
8	Cable for Datex-Ohmeda Aestiva/5	N-DISAEST	897228
8	Cable for Datex-Ohmeda Tonocap	N-DISTONO	897229
8	Cable for Datex-Ohmeda Smartvent 7900	N-DIS7900	8002597
8	Cable for Siemens Servo	N-DISS300	8002838
8	Cable for Datex-Ohmeda whiteline monitors	N-DISWHITE	8002840
8	Cable for Datex-Ohmeda Carestation	N-DISVENT	M1023823
9	Strain relief	N-DISxxx	897443
10	Screw M2.5¥10		61615

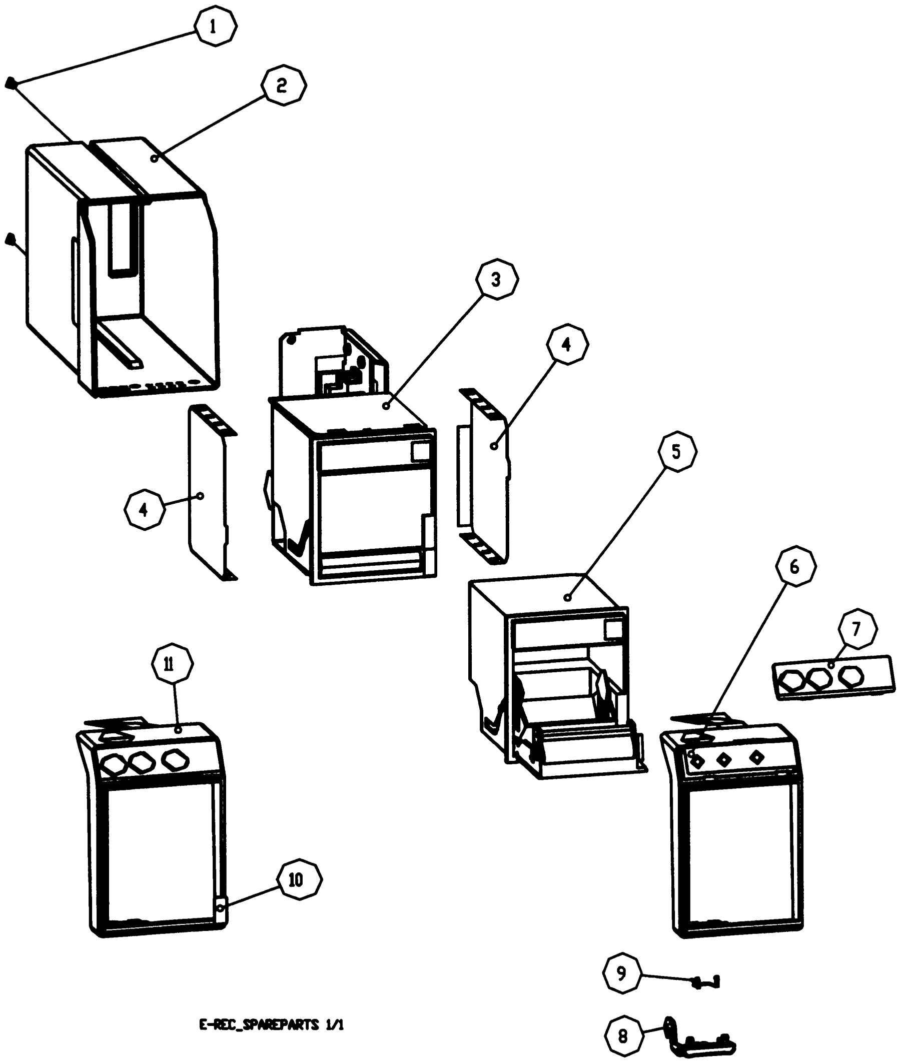
13 Interface Module, E-INT



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035
3	EMC cover	884099
4	Metal frame	879184
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
6	Interface board, M-INT	890843
7	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
8	NUT M3 STZN	63116
9	Front Chassis, E-INT, E-MEM	M1021025

Item	**Description**	**Order No.**
10	Connector Plate, E-INT	M1012031
11	SCREW, thread forming, M2.5x10mm, WN1423, torx head, flat countersunk head, steel	M1025318
12	Flat Cable, E-INT, Cable assembly	M1025419
13	Block screw for cables, M-INT	891033
14	Front Cover, E-INT	M1025582
15	Latch	M1021039
16	Torsion Spring	M1020935
17	Front Chassis Unit, E-INT	M1025416

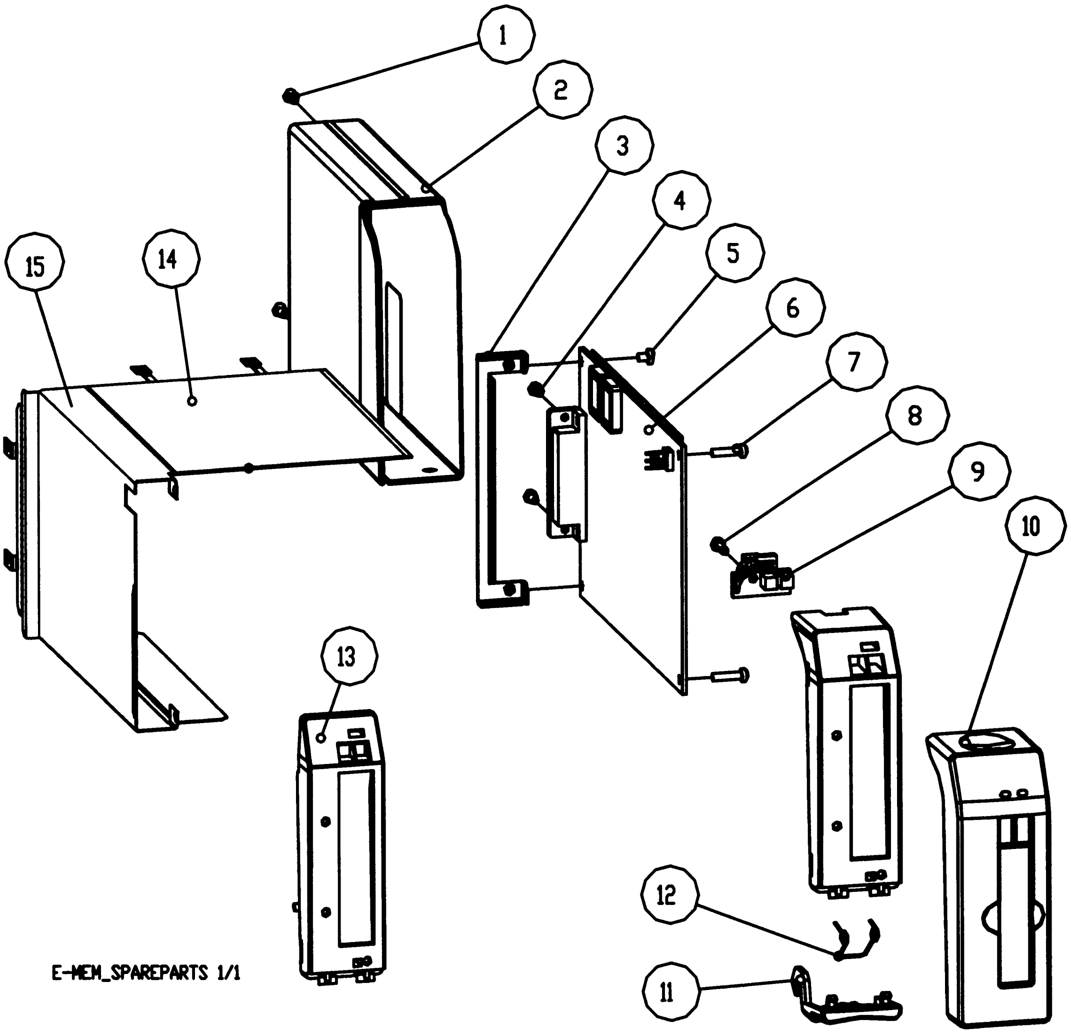
14 Recorder Module, E-REC



Item	Description	Order No.
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Double	M1021037
3	Recorder Board with Body Plate, E-REC, Spare Product assembly	M1029379
4	Side Plate, E-REC	M1021055
5	OEM-ITEM, Thermal printer 50mm, AR42A, Serial connection 76.8 KBaud, White	M1028145
6	Membrane Keyboard, E-REC	M1021051
7	Front Cover, DA, E-REC	M1025398
7	Front Cover, DE, E-REC	M1025399

Item	**Description**	**Order No.**
7	Front Cover, EN, E-REC	M1025400
7	Front Cover, ES, E-REC	M1025401
7	Front Cover, FR, E-REC	M1025402
7	Front Cover, HU, E-REC	M1046413
7	Front Cover, IT, E-REC	M1025403
7	Front Cover, JA, E-REC	M1025404
7	Front Cover, NL, E-REC	M1025405
7	Front Cover, NO, E-REC	M1025406
7	Front Cover, PL, E-REC	M1025407
7	Front Cover, PT, E-REC	M1025408
7	Front Cover, SV, E-REC	M1025409
7	Front Cover, FI, E-REC	M1025410
8	Latch	M1021039
9	Torsion Spring, E-REC, E-GAS	M1024356
10	PANEL, Name sticker for E-REC	M1032491
11	Front Chassis Unit, E-REC	M1026338

15 Memory Module, E-MEM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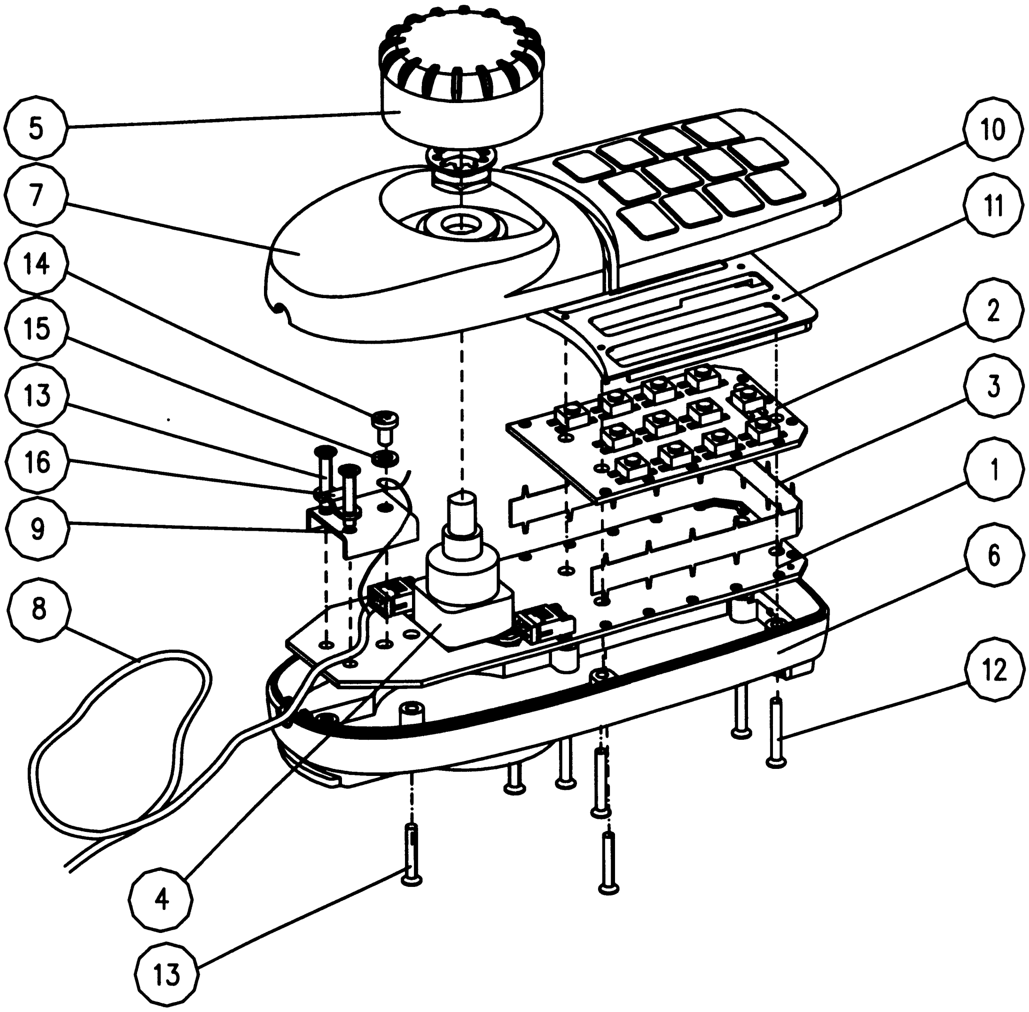
E-MEM_SPAREPARTS 1/1

Item	Description	Order No.
	AS/3 MemCard, Menu, EN	893860
	AS/3 MemCard, Data, EN	887045
	AS/3 MemCard, Menu, FR	893861
	AS/3 MemCard, Data, FR	887047
	AS/3 MemCard, Menu, JA	893862
	AS/3 MemCard, Data, JA	890349
	AS/3 MemCard, Menu, DE	895880
1	SCREW, machine, M3x8mm, DIN965, torx head, flat countersunk head, steel	606024
2	Module Casing, Single	M1021035

Item	**Description**	**Order No.**
3	Metal frame	879184
4	Cross recess screw UNC 4-40	61841
5	SCREW,CYLINDER HEAD,MRT,M3x6,STZN (FZB),8.8,M,DIN7985 TORX	605000
6	MEMORY BOARD, E-MEM	M1028886
7	SCREW, screw for plastic, x12mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x12mm, ST-ZN, WN1452	628729
8	SCREW, screw for plastic, x8mm, WN1452, torx head, pan head, steel, zinc, SCREW-PT, PAN-HEAD, TORX, 3.0x8mm, ST-ZN, WN1452	628727
9	LED board, M-MEM	885252
10	Front Cover, DE, E-MEM	M1027457
10	Front Cover, EN, E-MEM	M1027456
10	Front Cover, FR, E-MEM	M1027458
10	Front Cover, JA, E-MEM	M1027459
11	Latch	M1021039
12	Torsion Spring	M1020935
13	Front Chassis Unit, E-MEM	M1027451
14	Insulation plate, M-MEM	886656
15	EMC cover, M-MEM	885860

16 Remote controller, K-CREMCO, rev. 00, 01

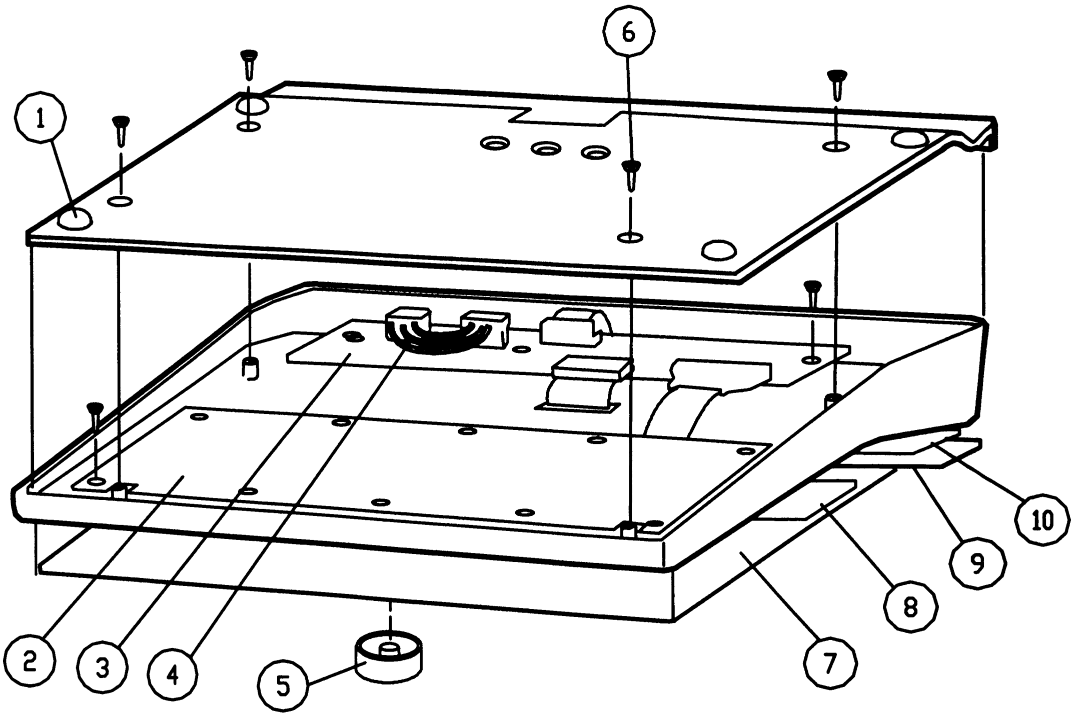


Item	Description	Order No.	Replaced by
1	CPU board, K-REMCO	890368	
2	Keyboard PCB, K-REMCO	890371	
3	Connecting plate	891427	
4	Rotary wheel	891036	
5	ComWheel (green); K-REMCO; S/5	898940	
6	Bottom (Munsell N9); K-REMCO; S/5	898938	
7	Cover (Munsell N9); K-REMCO; S/5	898939	
8	K-REMCO - CM cable	891965	
9	Bridge for cable	893235	
10	Front Panel sticker, DA; K-REMCO (rev.00), (rev.01; S/5)	892203	

Item	Description	Order No.	Replaced by
10	Front Panel sticker, DE; K-REMCO (rev.00), (rev.01; S/5)	892312	
10	Front Panel sticker, EN; K-REMCO (rev.00), (rev.01; S/5)	891425	
10	Front Panel sticker, ES; K-REMCO	892315	
10	Front Panel sticker, FI; K-REMCO (rev.00), (rev.01; S/5)	892317	
10	Front Panel sticker, FR; K-REMCO (rev.00), (rev.01; S/5)	892313	
10	Front Panel sticker, IT; K-REMCO (rev.00), (rev.01; S/5)	892316	
10	Front Panel sticker, JA; K-REMCO (rev.01) S/5	894962	
10	Front Panel sticker, NL; K-REMCO (rev.00), (rev.01; S/5)	892314	
10	Front Panel sticker, NO; K-REMCO (rev.00), (rev.01; S/5)	893553	
10	Front Panel sticker, PT; K-REMCO (rev.01); S/5	895233	
10	Front Panel sticker; SV; K-REMCO (rev.00), (rev.01; S/5)	892318	
11	Front panel framework	891426	
12	Slotted recess screw M2.5x22	61218	
13	Cross recess PT-screw M2.5x16	628719	
13	Cross recess PT-screw M2.5x16	628719	
14	Cross cylinder-head screw M3x6	61721	
15	Shake proof washer m3.2	63611	
16	Cable binder	546454	

17 Anesthesia keyboards, K-ARK, K-ARKB

17.1 K-ARK rev. 00, 01, 02

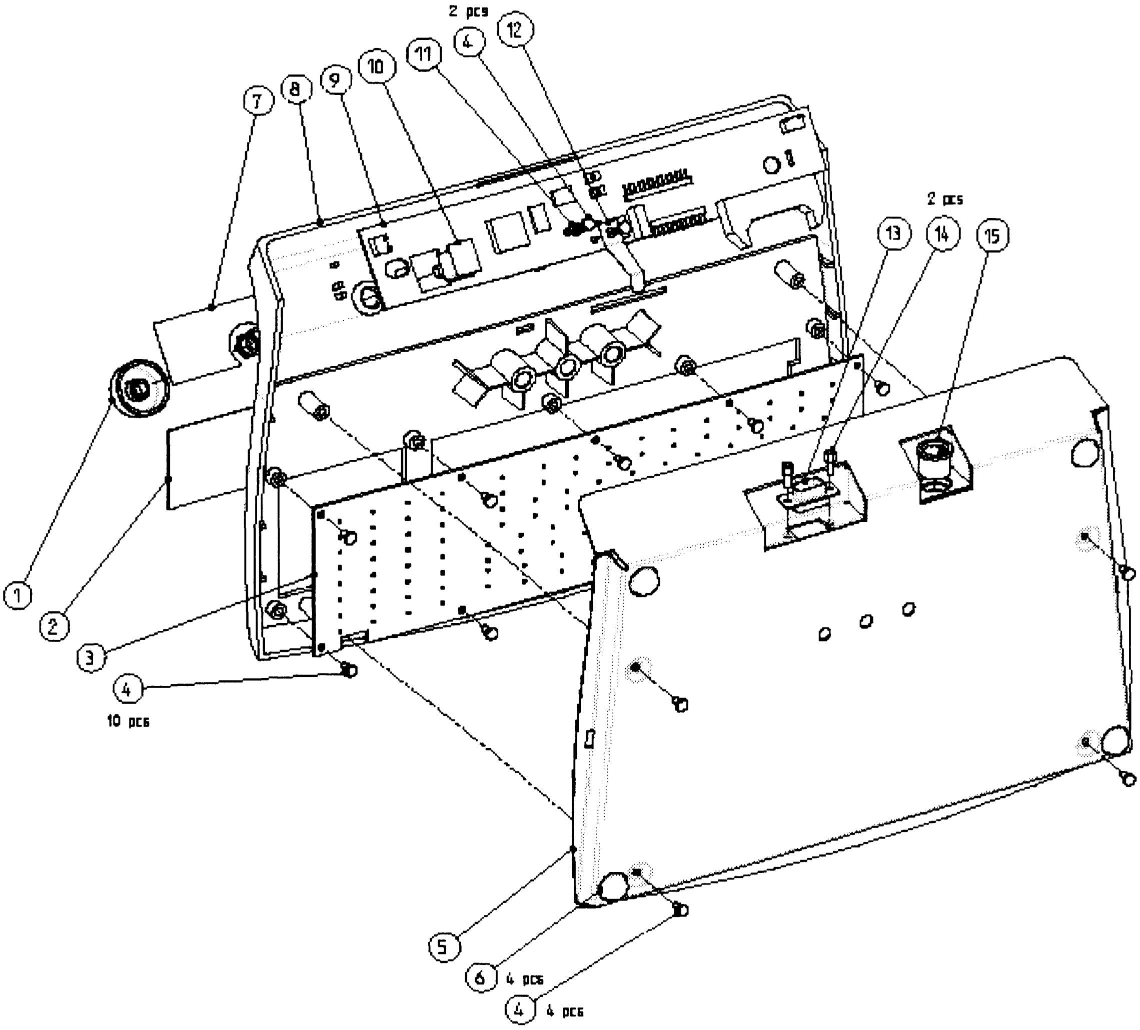


Item	Description	Order No.	Replaced by
1	Sticker-pad,diam 16,height 8	65142	
2	Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB	884178	
3	Command board PCB, K-ARK (rev.01-02)	893944	
3	Controller board, K-ARK (rev.00), K-CENTRALB	884177	
4	Rotary wheel	879872	
5	ComWheel cover and spring	879191	
6	Cross cylinder-head screw M3x6	61721	
7	Lower Front Panel sticker, IT; K-ARK (rev.02)	893608	
7	Lower Front Panel sticker, SCA; K-ARK (rev.00-01)	884632	893807
7	Lower Front Panel sticker, DA; K-ARK (rev.02)	893611	
7	Lower Front Panel sticker, DE; K-ARK (rev.00-01)	885133	893604
7	Lower Front Panel sticker, DE; K-ARK (rev.02)	893604	
7	Lower Front Panel sticker, EN; K-ARK (rev.00-01)	884017	893603
7	Lower Front Panel sticker, EN; K-ARK (rev.02)	893603	

Item	Description	Order No.	Replaced by
7	Lower Front Panel sticker, ES; K-ARK (rev.00-01)	886198	893607
7	Lower Front Panel sticker, ES; K-ARK (rev.02)	893607	
7	Lower Front Panel sticker, FI; K-ARK (rev.00-01)	888862	893609
7	Lower Front Panel sticker, FI; K-ARK (rev.02)	893609	
7	Lower Front Panel sticker, FLE; K-ARK (rev.00-01)	886161	893114
7	Lower Front Panel sticker, FLE; K-ARK (rev.02)	893114	
7	Lower Front Panel sticker, FR; K-ARK (rev.00-01)	884406	893605
7	Lower Front Panel sticker, FR; K-ARK (rev.02)	893605	
7	Lower Front Panel sticker, IT; K-ARK (rev.00-01)	886911	893608
7	Lower Front Panel sticker, NL; K-ARK (rev.00-01)	886282	893606
7	Lower Front Panel sticker, NL; K-ARK (rev.00-01)	892200	893611
7	Lower Front Panel sticker, NL; K-ARK (rev.02)	893606	
7	Lower Front Panel sticker, NO; K-ARK (rev.02)	893552	
7	Lower Front Panel sticker, PT; K-ARK (rev02)	895261	
7	Lower Front Panel sticker, SCA; K-ARK (rev.02)	893807	
7	Lower Front Panel sticker, SV; K-ARK (rev.00-01)	885916	893610
7	Lower Front Panel sticker, SV; K-ARK (rev.02)	893610	
8	Membrane keypad, lower, K-ARK	879964	
9	Upper Fro Panel sticker, ES; K-ARK (rev.01)	892329	893598
9	Upper Fro Panel sticker, FI; K-ARK (rev.01)	892331	893600
9	Upper Front Panel sticker, DE; K-ARK (rev.01)	892326	893595
9	Upper Front Panel sticker, ES; K-ARK (rev.00)	886200	
9	Upper Front Panel sticker, FR; K-ARK (rev.00)	884731	
9	Upper Front Panel sticker, FR; K-ARK (rev.01)	892327	893596
9	Upper Front Panel sticker, DA; K-ARK (rev.01)	892199	893602
9	Upper Front Panel sticker, DA; K-ARK (rev.01)	892199	893602
9	Upper Front Panel sticker, DA; K-ARK (rev.02)	893602	
9	Upper Front Panel sticker, DE; K-ARK (rev.00)	885140	
9	Upper Front Panel sticker, DE; K-ARK (rev.02)	893595	
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.00)	881648	
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.01)	892350	893594
9	Upper Front Panel sticker, EN, SCA; K-ARK (rev.02)	893594	
9	Upper Front Panel sticker, ES; K-ARK (rev.02)	893598	

Item	Description	Order No.	Replaced by
9	Upper Front Panel sticker, FI; K-ARK (rev.00)	888861	
9	Upper Front Panel sticker, FI; K-ARK (rev.02)	893600	
9	Upper Front Panel sticker, FR; K-ARK (rev.02)	893596	
9	Upper Front Panel sticker, IT; K-ARK (rev.00)	886910	
9	Upper Front Panel sticker, IT; K-ARK (rev.01)	892330	893599
9	Upper Front Panel sticker, IT; K-ARK (rev.02)	893599	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.00)	886162	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.00)	886162	
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.01)	892328	893597
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.01)	892328	893597
9	Upper Front Panel sticker, NL, FLE; K-ARK (rev.02)	893597	
9	Upper Front Panel sticker, NO; K-ARK (rev.02)	893551	
9	Upper Front Panel sticker, PT; K-ARK (rev.02)	895260	
9	Upper Front Panel sticker, SV; K-ARK (rev.00)	885915	
9	Upper Front Panel sticker, SV; K-ARK (rev.01)	892332	893601
9	Upper Front Panel sticker, SV; K-ARK (rev.02)	893601	
10	Membrane keypad, K-VHC14	879373	

17.2 Anesthesia recordkeeping keyboard, K-ARKB rev. 00


2 pcs
4
12
7
8
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2 pcs
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1
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10 pcs
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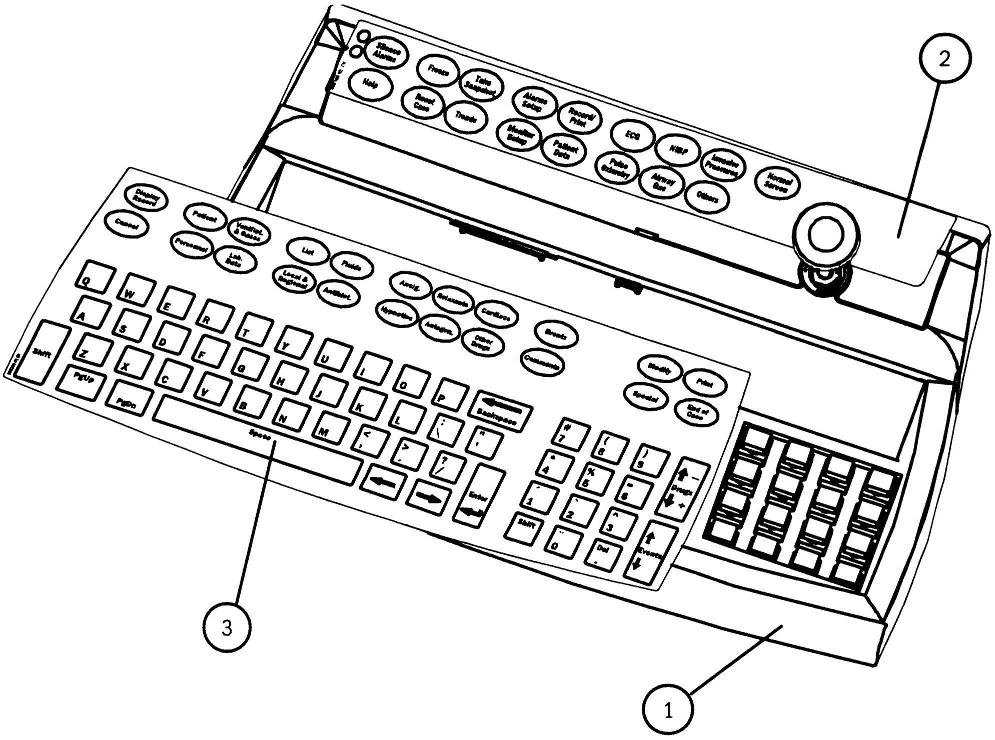
6 4 pcs
4 4 pcs

Item	Description	Order No.	Replaced by
1	ComWheel; S/5	898794	
2	Membrane keypad, lower, K-ARKB; S/5	8000006	
3	Alpha-numeric Keyboard PC-board, K-ARK (rev.00-01), K-CENTRALB	884178	
4	Cross cylinder-head screw M3x6	61721	
5	Bottom plate, K-ARKB; S/5	898392	
6	Sticker-pad,diam 16,height 8	65142	
7	Membrane keypad, K-ARKB; S/5	8000050	
8	Keyboard casing, K-ARKB; S/5	898391	
9	Command bar board, K-ARKB; S/5	8000054	

Item	Description	Order No.	Replaced by
10	Opto-encoder, rotary switch,16-positions, push button, metal shaft, 4inch ribbon cable and connector	113291	
11	Shake proof washer m3.2	63611	
12	Emc plate, K-ARKB; S/5	8000960	
13	Output connector cable, K-ARKB; S/5	8000098	
14	D-female screw lock	640624	
15	Connection cable PC-KB, K-ARKB;S/5	8000097	

17.2.1 S/5 front panel stickers



K-ARKB S/5 front panel stickers

Item	Description	Order No.	Replaced by
1	Keyboard casing, K-ARKB; S/5	898391	
2	Upper Front Panel sticker, DA; K-ARKB (rev.00); S/5	898369	
2	Upper Front Panel sticker, DE; K-ARKB (rev.00); S/5	898378	
2	Upper Front Panel sticker, EN; K-ARKB (rev.00); S/5	898368	
2	Upper Front Panel sticker, EN; K-ARKB (rev.00); S/5	898368	
2	Upper Front Panel sticker, ES; K-ARKB (rev.00); S/5	898372	
2	Upper Front Panel sticker, FI; K-ARKB (rev.00); S/5	898375	

2	Upper Front Panel sticker, FR; K-ARKB (rev.00); S/5	898370	
2	Upper Front Panel sticker, IT; K-ARKB (rev.00); S/5	898373	
2	Upper Front Panel sticker, JA; K-ARKB (rev.00); S/5	8000373	
2	Upper Front Panel sticker, NL; K-ARKB (rev.00); S/5	898371	
2	Upper Front Panel sticker, NL; K-ARKB (rev.00); S/5	898371	
2	Upper Front Panel sticker, NO; K-ARKB (rev.00); S/5	898377	
2	Upper Front Panel sticker, PT; K-ARKB (rev.00); S/5	898374	
2	Upper Front Panel sticker, SV; K-ARKB (rev.00); S/5	898376	
3	Front Panel sticker, lower, BE, NL; K-ARKB; S/5	898797	
3	Front Panel sticker, lower, DA; K-ARKB (rev.00); S/5	898390	
3	Front Panel sticker, lower, DE; K-ARKB (rev.00); S/5	898381	
3	Front Panel sticker, lower, EN; K-ARKB (rev.00); S/5	898380	
3	Front Panel sticker, lower, ES; K-ARKB (rev.00); S/5	898384	
3	Front Panel sticker, lower, FI; K-ARKB (rev.00); S/5	898387	
3	Front Panel sticker, lower, FR; K-ARKB (rev.00); S/5	898382	
3	Front Panel sticker, lower, IT; K-ARKB (rev.00); S/5	898385	
3	Front Panel sticker, lower, JA; K-ARKB (00); S/5	8000374	
3	Front Panel sticker, lower, NL; K-ARKB (rev.00); S/5	898383	
3	Front Panel sticker, lower, NO; K-ARKB (rev.00); S/5	898389	
3	Front Panel sticker, lower, PT; K-ARKB (rev.00); S/5	898386	
3	Front Panel sticker, lower, SKAND; K-ARKB; S/5	898796	
3	Front Panel sticker, lower, SV; K-ARKB (rev.00); S/5	898388	

17.3 Keyboard Interface Board, B-ARK

Item	**Item description**	**Order No.**
	Grounding plate, blank/narrow	885198
	Block screw for cables	546096

For your notes: